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THE AIR SEASONING OF WESTERN SOFTWOOD LUMBER

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INTRODUCTION

A real need exists in the lumber industry for a concrete presentation of efficient air-seasoning methods for western softwood lumber, including a review of the general principles that govern the drying of wood and their application to yard drying. Air-seasoning losses in the West, both in quantity and quality of the product, can be reduced. The average drying time can be shortened, with a consequent faster overturn of stocks. Shipping weights can be lowered and final moisture-content requirements more nearly attained. Moreover, highly competitive conditions in industry make essential all practicable improvement and economy in lumber manufacture, as well as a product of the highest possible utility and one that meets consumer requirements satisfactorily.

The import of such considerations to the lumber industry of the West is evident in view of the fact that 35 per cent of the total annual cut in its four [1] principal producing regions is air seasoned, or approximately 4,500,000,000 board feet, at a rough valuation of $120,000,000.

[1] Douglas fir region of western Oregon and western Washington, "Inland Empire," California pine region, and redwood region.

TABLE 1.—*Average annual production of western softwood lumber by regions*[1]

[In millions of board feet]

Kind of wood	Douglas fir region	Inland Empire pine region	California pine region	California redwood region	Total
Incense cedar (Libocedrus decurrens)			32		32
Western red cedar (Thuja plicata)	218	33			251
Douglas fir (Pseudotsuga taxifolia)	6,539	292	103	104	7,038
White fir[2]	17	73	183	16	289
Western hemlock (Tsuga heterophylla)[3]	819	9		1	829
Western larch (Larix occidentalis)	1	272			273
Lodgepole pine (Pinus contorta)		5			5
Sugar pine (Pinus lambertiana)[4]	8		214		222
Western white pine (Pinus monticola)[5]	1	393			394
Western yellow pine (Pinus ponderosa)[6]	16	1,023	846		1,885
Redwood (Sequoia sempervirens)				536	536
Sitka spruce (Picea sitchensis)	337			2	339
Engelman spruce (P. engelmannii)		25			25
Total	7,956	2,125	1,378	659	12,118

[1] Figures (rounded) based on five-year production records; Douglas fir region includes western Oregon and Washington; Inland Empire pine region includes Montana, Idaho, eastern Oregon and eastern Washington; California pine region includes California, Nevada, and Clamath Falls district of Oregon; California redwood region includes redwood belt in California.

[2] Includes the following species: White fir (*Abies concolor*), lowland white fir (*A. grandis*), silver fir (*A. amabilis*), red fir (*A. magnifica*), alpine fir (*A. lasiocarpa*), and noble fir (*A. nobilis*).

[3] West Coast hemlock.

[4] California sugar pine.

[5] Idaho white pine.

[6] Pondosa pine, California white pine.

The air seasoning of lumber is, however a complex problem if anything like real efficiency is to be obtained. In working out the proper solution five distinct objectives must be kept constantly in mind:

1. Minimum depreciation of stock.
2. Rapid rate of drying.
3. Low, uniform final moisture content.[2]
4. Economy in operating cost.
5. Reasonable yard space.

Other complications of the problem must also be recognized. The various species, grades, and sizes of stock require individual consideration. Owing to climatic and other differences, the answer for one yard will not always hold for another. The effects of seasonal weather variation must also be provided against by each yard separately.

Maximum attainment of any one of the five principal objectives may often preclude the full realization of the others. Since actual efficiency in air seasoning must in the final analysis be measured by the profit-and-loss yardstick, it is necessary that these five objectives be adequately balanced to the best advantage of the producer.

[2] The fact that wood shrinks and swells with changes in moisture content makes it highly desirable that seasoning result in a final moisture content suitable for the conditions of final use, but absolute attainment in this direction is hardly possible on account of the varied purposes for which wood is employed and the wide range of atmospheric conditions under which it is used. This can be illustrated in a concrete way. Wood thoroughly air-dried has a moisture content at Galveston, Tex., of about 17.5 per cent and at Phoenix, Ariz., of 7.5 per cent. In the general Middle West territory wood, to give the most satisfactory results, should have a moisture content of 6 to 8 per cent for interior work and 12 to 15 per cent for outside use. These differences indicate forcibly that the final moisture-content problem is a difficult one, but they also emphasize its importance to the operator.

A great variety of air-seasoning methods have come into use during the long period of development in the lumber industry. Observations of much value have been accumulated by those of experience in the industry; and yet to-day, after many years of air-seasoning practice, a wide difference of opinion exists among operators as to the relative value of many of the basic principles involved. There is urgent need for authentic and usable information based on careful studies.

It is obvious that the solution of the air-seasoning problem can not be found in any set of "cut-and-dried" rules. The chief aim of this bulletin is to present those general principles which can be applied by the lumberman in the manner that will best meet his own specific conditions and problems. No attempt is made to present the detailed data in substantiation of the conclusions given. The conclusions are based on surveys and study of current practice and on intensive air-seasoning investigations by the Forest Service within the four western lumber-producing regions.[3]

IMPORTANT PRINCIPLES OF WOOD DRYING AND THEIR GENERAL APPLICATION

OCCURRENCE OF MOISTURE IN WOOD

Moisture in wood, or sap, is chiefly water with small percentages of organic and mineral matter present in soluble form. In the sapwood these materials are largely sugars, but in the heartwood they are principally tannins, resins, and dyestuffs. For all practical purposes in the drying of wood sap can be considered as water, since only very small quantities of the other materials pass off in evaporation.[4]

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[3] Acknowledgment is made by the authors to other members of the Forest Service, particularly those of the Forest Products Laboratory, who have contributed in a large measure to present knowledge relating to the principles of drying wood. Acknowledgment is also made to C. Burdette Green, formerly a member of the Forest Service, for his very considerable contributions of air-seasoning data from California.

[4] The amount of moisture in wood, or the moisture content, is expressed in terms of percentage of the oven-dry weight of the wood. Thus, if the moisture content of a green board is 71 per cent, there are by weight 71 parts of water to 100 parts of oven-dry wood. Similarly, should the moisture content of a board happen to be exactly 100 per cent, the weight of the moisture and that of the oven-dry wood would be equal. The average moisture content of a lot of lumber may be determined in the following manner:

Select representative pieces—about 1 out of every 100 to 500 pieces—with a fair representation of both heartwood and sapwood.

At a point about 2 feet from one end of each piece, cut out a section three-fourths to 1 inch wide, making the cut at a place free from knots, rot, pitch streaks, or other defects. Trim off all slivers from this section or sample.

Weigh the samples immediately and carefully on a delicate balance. This is the original weight.

Place samples in an oven heated to 212° F., or, if an oven is not available, on hot steam pipes; but do not scorch or bake them.

When samples have reached a constant weight, as can be determined by repeated weighing, remove them from the oven. (After a little experience the time required to reach constant weight can be estimated, and thus repeated weighings may be avoided. Twenty-four hours should be the maximum time necessary with softwoods.) This final weight is the oven-dry weight.

Subtract the oven-dry weight from the original weight. The difference is the loss in moisture.

Divide the difference by the oven-dry weight and multiply by 100. This gives the percentage of moisture contained in the wood based on the oven-dry weight.

EXAMPLE

Original weight = 284.7 grams.
Oven-dry weight = 180.2 grams.
284.7 grams − 180.2 grams = 104.5 grams, or the moisture lost.
$104.5 \div 180.2 = .580 \times 100 = 58.0$ per cent moisture originally in the wood.
(For convenience and accuracy the gram is often used as the unit of measurement, but other units, such as the ounce, may be employed.)

Moisture is held in green or wet wood in two ways. It is contained within the otherwise practically empty cell cavities, and it is absorbed in the cell walls. The cell water is called "free" water; that in the cell walls may be termed "imbibed" water. Free water is found in the cell cavities only when the cell walls are fully saturated.

Shrinkage of wood takes place only with a loss of moisture and swelling with the absorption of moisture. But all loss of moisture is not accompanied by shrinkage. As wood dries, it first gives up its free water. After the cell cavities become empty, the moisture in the saturated cell walls is drawn off. Wood does not start to shrink until the cell walls begin to lose moisture.

The point at which the cell cavities are empty but the cell walls are still saturated is thus an important one in drying. It is known as the fiber-saturation point. The moisture content at this point varies from 20 to 35 per cent, but for most woods is between 25 and 30 per cent. In actual practice, of course, the cells near the surface fall below this point before those on the interior have reached it, and the outer wood tends to shrink before the inner. Such a state is often the cause of serious drying troubles.

Free water is present in both the heartwood and sapwood of most living trees but in greatly differing quantity. Sapwood usually contains more moisture than heartwood. Butt logs ordinarily have a higher moisture content than top logs. Contrary to common belief, the quantity of moisture in green wood has little seasonal variation. Species and locality of growth, however, have an important bearing upon it.

Variation of moisture content was very marked in the many determinations of green wood made in the air-seasoning investigations upon which this study is based. Differences between species were, of course, large, but in all species the select grades contained more moisture than the common grades, owing to the greater proportion of sapwood in the better class of stock. The moisture content of western white pine averaged about 84 per cent for selects and 75 per cent for common; that of sugar pine 190 and 75 per cent; that of white fir 200 and 90 per cent; and that of redwood 200 and 70 per cent. The moisture content of coast Douglas fir probably ranges from 53 to 32 per cent and that of western hemlock from 120 to 28 per cent. Variation resulting from locality of growth is well illustrated by the moisture content of western yellow pine. The moisture content of stock from California ranged from 185 to 100 per cent, whereas that in stock from the Inland Empire ranged from 115 to 80 per cent.

MOVEMENT OF MOISTURE IN WOOD

As already stated, wood upon drying loses first its free water and then that which is absorbed in the cell walls. The pores themselves have very little to do with drying or the movement of moisture in wood. The moisture does not flow out of the pores of wood to the surface, but comes to the surface only along the cell walls. Thus, because of the nature of wood structure, the end grain of wood loses moisture more rapidly than does the side grain, and flat or plain-

sawed faces lose it more rapidly than do vertical-grain or quarter-sawed faces.

For an understanding of the air-seasoning process, this general description of the movement of moisture in wood is sufficient. It can be assumed that the moisture tends to distribute itself evenly through the wood, moving from the moist regions to the drier ones. The really important facts are that the temperature and humidity of the atmosphere at the surface of the wood are controlling factors, and that circulation of the air is of extreme importance in maintaining and modifying these.

EFFECT OF HUMIDITY ON DRYING

Wood possesses the property of giving off or taking on moisture from the surrounding atmosphere until the moisture in the wood comes to a balance with that in the air. The humidity or water vapor in the air is, therefore, very important in the drying of wood, and a general understanding of this relationship between humidity and moisture content of wood is essential.

The weight of the water vapor contained in a cubic foot of air is the absolute humidity and is usually expressed in number of grains. This does not, however, indicate the drying capacity of the air, for the ability of air to hold water, or its saturation point, varies greatly with the temperature, as is illustrated by Table 2. This ability of air to dry wood, or any other substance, varies according to the additional moisture it can hold before becoming saturated. The vapor in the air expressed as a percentage of the saturation point for the same temperature is called the " relative humidity " and indicates the comparative drying capacity of air. The lower humidities represent dry air and the higher ones moist air. As used in this bulletin, the term " humidity " alone refers invariably to relative humidity.

TABLE 2.—*Cubic foot moisture capacity of air at different temperatures*

Temperature	Moisture
°*F.*	*Grains*
20	1. 24
40	2. 86
60	5. 80
80	11. 10
100	20. 00

Marked changes in relative humidity are evident from season to season, and also the usual daily fluctuations must be taken into account. Because of its tendency to come to definite balance with the surrounding air wood is, under ordinary atmospheric conditions, practically always undergoing at least slight changes in moisture content. This same tendency accounts for the differences in final moisture content of thoroughly air-dry wood at different times of the year. The pick-up in moisture content of lumber left piled in the yard over winter is likewise explained. Table 3 shows the ultimate moisture content of wood if kept under exact humidity and temperature conditions.

The rate of drying depends largely upon the relative humidity. At a low humidity, evaporation is rapid; at a high humidity, it is slow. Relative humidity alone, as indicated, does not altogether determine the rate of drying. The temperature and the circulation of the air also influence the rate of evaporation.

TABLE 3.—*Ultimate moisture content of wood at different temperatures and degrees of relative humidity*[1]

Relative humidity	Moisture content at three temperatures		
	70° F.	140° F.	212° F.
Per cent	*Per cent*	*Per cent*	*Per cent*
20	4.5	3.3	2.2
30	6.0	4.5	2.9
40	7.7	5.9	3.9
50	9.3	7.1	4.9
60	11.2	8.8	6.2
70	13.5	10.7	8.0
80	17.0	14.0	10.5
90	22.2	18.2	14.0
100	32.0	26.2	21.0

[1] Prepared by the Forest Products Laboratory, Forest Service.

EFFECT OF TEMPERATURE ON DRYING

The temperature of the air surrounding wood affects drying in a number of ways. Heat is always consumed when evaporation takes place, and must be continuously supplied by the air, if evaporation is to be kept up. Also, as has been pointed out, an increase in temperature of the air increases its capacity to hold moisture and thus hastens evaporation. Below the fiber-saturation point a greater degree of heat is required to separate water from wood, this requirement increasing as the wood becomes drier.

These effects of heat or the temperature of the air upon the drying process explain certain conditions encountered in air seasoning. For example, even during the coolest months of the year, loss of moisture is comparatively rapid until a moisture content of about 30 per cent is reached, which corresponds to the fibre-saturation point. Then an abrupt decrease in the drying rate takes place.

EFFECT OF AIR CIRCULATION ON DRYING

Air circulation plays a big part in the drying process. As wood dries and evaporation uses up heat and increases the amount of moisture in the surrounding air, circulation of air is required to sustain the supply of heat necessary for evaporation and to remove the evaporated moisture. Circulation is thus a real factor in the drying of wood by any method and is particularly important in air seasoning.

CONDITIONS OUTSIDE THE PILE THAT INFLUENCE AIR SEASONING

Since the air seasoning of lumber is dependent upon the temperature, humidity, and circulation of the surrounding air, regional climatic conditions, modified as these are locally by elevation, topog-

raphy, drainage, and bodies of water, constitute the primary influences in air drying. No matter what the yard methods, nor how efficiently air-seasoning practice is designed to control the drying conditions within the lumber pile, a warm, dry, windy climate will cause faster drying and lower final moisture content than will a cool, damp, calm climate.

The considerable variation of geographic and climatic factors between the several western lumber-producing regions and also between yards in the same region, and the influence of such variations upon the air-seasoning process are clearly illustrated by the data in Figures 7 to 10 showing the effect of different weather conditions upon the actual drying. Even though these natural conditions are subject to little control, a knowledge of them and recognition of their effects on drying are essential to the intelligent selection of a yard site, the proper laying out of the drying yard, and the development of effective piling methods.

The aim of air-seasoning practice must necessarily be to employ the favorable natural elements to the greatest possible advantage and to minimize the effects of the unfavorable elements. Granted that absolute control of drying conditions is impossible, much can yet be done if the general principles and objectives of drying are understood and properly coordinated. For example, a certain amount of heat is transmitted to the lumber from the direct rays of the sun, which reach at least a part of the pile during some portion of the day. The outside area of the pile which receives direct sunlight as well as the length of the daily period during which the sun can reach the sides or ends of the pile can be controlled to some extent by such methods as varying the spacing at the sides, front, and back of the pile and determining the direction of these openings.

CIRCULATION OF AIR WITHIN THE PILE

The functions and importance of circulation in air seasoning have already been indicated. Circulation of air is the only drying factor that is subject to direct methods of control, and, in turn, it largely controls the effects of heat and humidity within the lumber pile.

The movement or circulation of air in a lumber pile is of two general types. Horizontal circulation is dependent upon and is caused primarily by the local wind currents. Vertical circulation, on the other hand, is an individual internal movement.

Horizontal circulation can be regulated to some extent by yard layout, foundation construction, and piling methods. Arrangement and spacing of pile alleys, rear alleys, and the intervals between piles on the same alley directly affect the movement of the local air currents. Likewise, the clearance under the pile foundations exerts an appreciable influence. And the actual inlet and outlet of the wind currents to and from the pile are greatly affected by the method of pile construction.

Vertical circulation in the lumber pile is a drying factor of the utmost importance and should be thoroughly understood. As the green stock in the pile dries, the evaporation uses up heat. The air, thus becoming cooler and heavier, tends to drop gradually toward the bottom of the pile. Pile construction should therefore be de-

signed to aid this natural movement, permitting as far as possible an unobstructed and continuous downward flow of air. To obtain benefits from vertical circulation, it must be positive, and not only at a single point but throughout the pile from one side to the other. This makes it essential that vertical air channels be ample and well distributed.

This natural downward movement of cool, moist air in a lumber pile results, however, in stagnation and slow drying in the lower section unless proper means are provided to insure the removal of such air. Therefore, horizontal circulation, particularly in the lower portion of the pile and beneath it, is a necessary adjunct to vertical circulation. If adequate means for circulation both in the yard and in and under the pile are provided, the air cooled and laden with

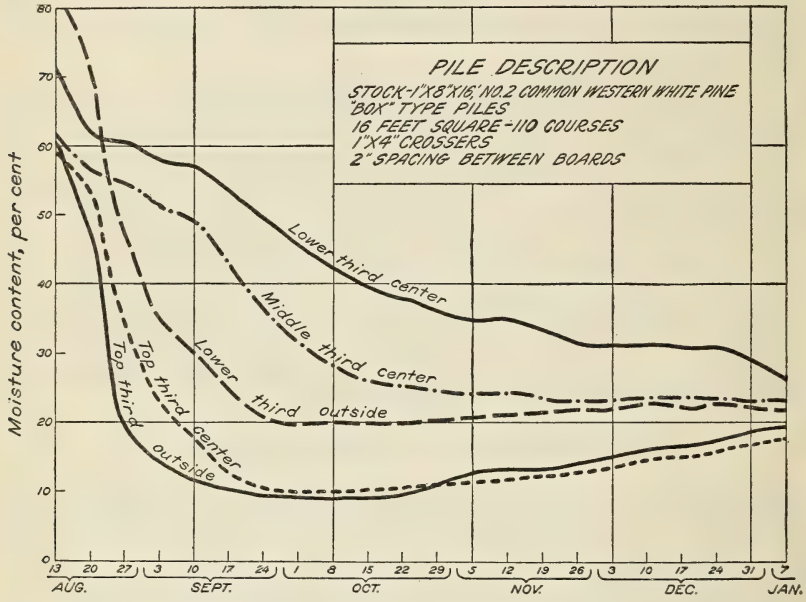


FIG. 1.—Comparative rate of drying in different parts of typical lumber pile

moisture by evaporation is replaced by warmer and drier air from the outside. This movement toward the outside of the pile is made possible by wind currents and to a lesser degree by the natural outward flow in the lower portion of the pile caused by the pressure of the downward movement.

There is much misconception of the nature of air movement in a lumber pile. If the natural tendency of the moist air to drop toward the bottom of the pile is not adequately provided for, drying in the lower part of the pile will lag behind that above, and serious drying troubles are almost certain to develop. The average drying time will be lengthened, a portion of the stock may never reach a thoroughly air-dry condition, and in pine lumber the liability to stain development will be increased. This lag in drying is well illustrated in Figure 1, which represents actual drying conditions in different parts of a typical lumber pile.

CAUSES AND CONTROL OF STOCK DEPRECIATION

The defects in lumber resulting from air seasoning are very definitely related to methods used in the drying process. An understanding of their causes will permit a better appreciation of the possibility and means of prevention. These defects may be grouped as those due to shrinkage and those due to fungi. Shrinkage defects include check, cup, warp-bow-twist, and loosening of knots. Defects caused by fungi include stains and decay.

SEASON CHECKS

Lumber checks as the result of uneven shrinkage. This, in turn, may be due to one or both of two causes, uneven drying or the inherent difference between radial and tangential shrinkage in wood.

Uneven drying is due commonly to the end grain of wood giving off moisture more rapidly than the side grain, to surface layers drying faster than those on the interior, or to the fully exposed portions of the board drying before adjacent sections not so exposed are able to lose their moisture.

Tangential shrinkage, or shrinkage in the direction of the rings, is on an average about twice as great as radial shrinkage or shrinkage across the rings. Table 4 gives this differential in shrinkage for each of the commercial western species.

TABLE 4.—*Radial, tangential, and volume shrinkage*[1] *of different woods from the green to the oven-dry condition, in percentage of green size*[2]

Western species	Shrinkage			Ratio of tangential to radial shrinkage	Western species	Shrinkage			Ratio of tangential to radial shrinkage
	Volume	Radial	Tangential			Volume	Radial	Tangential	
	Per cent	*Per cent*	*Per cent*			*Per cent*	*Per cent*	*Per cent*	
Incense cedar	7.6	3.3	5.7	1.73	White fir	10.2	3.4	7.0	2.06
Port Orford cedar	10.7	5.2	8.1	1.56	Western hemlock	11.6	4.5	7.9	1.76
Western red cedar	8.1	2.5	5.1	2.04	Western larch	13.2	4.2	8.1	1.93
Douglas fir, Rocky Mountain	10.6	3.6	6.2	1.72	Lodgepole pine	11.5	4.5	6.7	1.49
					Sugar pine	8.4	2.9	5.6	1.93
Douglas fir, Pacific coast	12.6	5.0	7.9	1.58	Western white pine	11.5	4.1	7.4	1.80
					Western yellow pine	10.0	3.9	6.4	1.64
Silver fir	14.1	4.5	10.0	2.22	Redwood	6.3	2.7	4.2	1.55
Lowland white fir	10.6	3.2	7.2	2.25	Sitka spruce	11.2	4.5	7.4	1.64
Noble fir	13.6	4.8	9.1	1.90	Engelmann spruce	10.4	3.4	6.6	1.94

[1] Radial shrinkage is at right angle to the annual growth rings, tangential shrinkage is in the direction of the growth rings.
[2] Data by the Forest Products Laboratory, Forest Service.

The end checking of lumber during air seasoning is very largely due to the uneven shrinkage which results from the exposed ends drying more rapidly than the adjacent portion. Not only does the end grain normally give off its moisture more rapidly than the side grain, but the side grain at or near the end of the board is covered top and bottom by the crosser and so is not exposed to the air. It follows that, to minimize end checking, ends of stock should be

shaded to decrease the rate of drying, and the area covered by the crosser should be reduced as much as practicable.

Season checks appearing on the faces of the stock result both from uneven drying and from the differential between tangential and radial shrinkage. With excessively rapid surface drying, the outer layers become much drier than those on the interior and tend to shrink before the inside portion is dry enough to do so. Stresses are thus set up in the piece which may cause checking either immediately or when the stock is run through the planer. Other stresses are set up when one section begins to shrink before an adjacent one is sufficiently dry to do so, and these result in checking in the drier section. Crossers are often responsible for this type of check in the stock. In plain-sawed pieces the face of the board nearer the heart of the tree is more subject to tangential shrinkage than the other face, and although the resultant tendency to cup is met by the weight of the pile holding the boards flat, the stresses set up may result in checking. The prevention of excessively rapid drying tends to reduce any form of checking, and a decrease in the area covered by the crosser will also aid materially.

CUP

The cupping of lumber may be caused by one side drying and shrinking more rapidly than the other, as when stock is piled two layers to the course and the exposed faces are dried to a lower final moisture content than is the other face. It may also be due to one side shrinking more than the other even when uniformly dried, as in flat-sawed lumber; in flat or tangentially sawed lumber the side toward the center of the tree shrinks less, causing the lumber to cup away from the center. In general, cupping may be held to the minimum by the prevention of too rapid drying and by allowing both faces of the stock to dry evenly.

WARP-BOW-TWIST

Warp-bow-twist is usually the result of uneven shrinkage caused by structural differences. Spiral or interlocked grain is commonly responsible. Minor defects of this class may result from uneven drying, which also can aggravate those due to the wood structure. Preventive measures are confined to decreasing the rate of drying and to the use of piling methods which will hold the stock firmly in place and in proper alignment.

LOOSENING OF KNOTS

Knots are loosened during seasoning as a result of the drying out of the cementing resins and gums and of differences in the shrinkage of the knots and the surrounding wood. In a plain-sawed board, the axis of the knot being at right angles to that of the tree, the knot shrinks away from the wood lengthwise of the board but does not do so appreciably in the direction of the board width. As shrinkage in the thickness of the board is greater than that along the axis of the knot, many knots are loosened when stock is machined. The loosening of knots can not be entirely avoided by any method of seasoning, since a certain type of knot is not directly connected

with the wood surrounding it. Depreciation from this source can be reduced somewhat in air seasoning by measures which prevent excessively rapid drying and extremely low final moisture content.

BLUE STAIN [5]

Blue stain does not materially affect the strength properties of wood. It is not an early stage of decay. It does, however, lower the value of the product for uses in which discolorations are objectionable or in which the wood is to receive a natural finish. In the air seasoning of western yellow pine, western white pine, and sugar pine, the prevention of blue stain is often the major drying problem.

The blue-stain organism does not attack the living tree, and in wood products the blued areas are confined to the sapwood, ending where the heartwood begins. Apparently, conditions favorable for the development of the fungi are limited to sapwood stock containing a suitable amount of moisture. The fact that some species of wood blue more readily than others has not been explained. Possibly the food or moisture conditions in the sap of different woods vary sufficiently to account for this selective action.

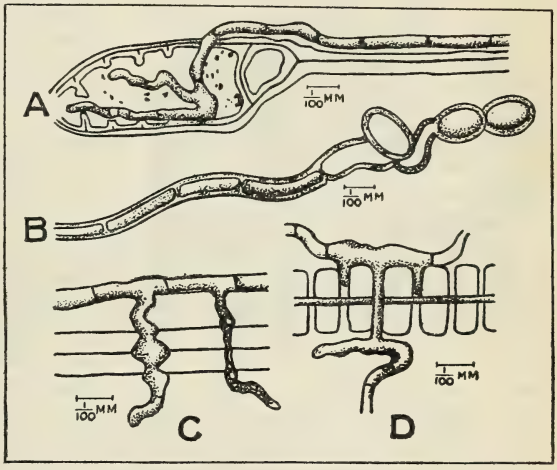


FIG. 2.—The threads (B) of a blue-stain fungus in shortleaf pine decomposing the medullary rays at A and penetrating the cell walls at C and D

Blue stain in its early development appears as spots or streaks. Later, as the fungus penetrates more deeply, the entire sapwood may be discolored. The defect is a discoloration of the stock due directly to the growth within the wood of minute threads of the blue-stain fungi. These fungi are very small plants which absorb their nourishment from the wood they inhabit, feeding principally upon the cell contents. As the fungus threads grow, they pass from one cell to another, usually through the thin parts of the cell wall but occasionally boring through the wood fiber. The blue-gray color appears only after these numerous small threads have reached a certain stage of development within the wood cells. (Figs. 2 and 3.)

Later on, when these threads feeding on the contents of the cell and to a slight extent on the cell walls have developed further, fruiting bodies comparable in some ways to the flowering part of a green

[5] Acknowledgment is made by the authors to E. E. Hubert, formerly assistant pathologist, Bureau of Plant Industry, who has contributed so materially to the present knowledge of the blue-stain fungi, for the material presented in this section.

plant are produced upon the surface of the wood. (Fig. 4.) These fruiting bodies, resembling small black hairs or bristles swollen at the base, A, appear as tiny black specks upon the blued wood. From them, minute spores, B, are ejected which, when carried about by the wind or other means, cause new infections by germinating on bright lumber green from the saw or on other favorable places.

Although the blue-stain organism may be present in certain logs before these are sawed into lumber, the chief source of infection is the fresh spores. Accordingly yard sanitation, including avoidance of the too frequent use of crossers, is highly important in blue-stain prevention.

The conditions for rapid development of blue stain are essentially the same as for the development of true wood-destroying fungi. Both require an abundant food supply, a comparatively high moisture content of the wood, and warm weather. Staining is always severe during rainy periods in the warmer seasons of the year when the air is humid and seasoning is correspondingly slow. Under such conditions, if proper piling and storage methods are not employed, very heavy staining may occur, particularly in fresh-cut stock.

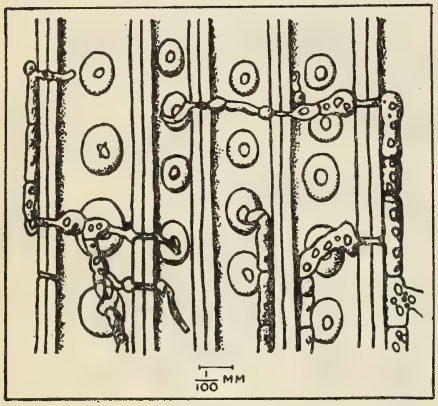


FIG. 3.—Young threads of the blue-stain fungus in the wood cells of Virginia pine, showing the direct penetration of the cell walls. In the lower center one thread is passing through a bordered pit. It is the presence of such threads within the cells that gives the blue color to the wood

It has been observed that these fungi grow best on substances which contain some acid, the acid of sour sap being very favorable for the development of the blue-stain organism. This explains why "souring" or "fermenting" of the sapwood is often advanced as the origin of the blue-stain blemish rather than the true cause, fungus development.

From the investigative work on the moisture requirements of the blue-stain organism thus far attempted, it seems safe to assume that there is little danger of sap-stain development in wood with a moisture content of 20 per cent or lower. In air seasoning the occurrence of this defect is primarily the result of insanitary yard conditions and slow drying. Preventive measures include sanitation and yard practice which will permit rapid drying, especially in the initial stages and in the lower third of the lumber pile.

Blue stain is the only stain of economic importance in the air seasoning of western softwood lumber and is a major problem only in drying the pines. In view of the general climatic conditions and the usual drying periods required in the West, decay need not be considered as an air-seasoning defect. Of course, incipient infections of decay that may cause trouble with the stock in later use should be guarded against, but any of the measures taken to reduce blue-stain development are also helpful in preventing decay.

AIR-SEASONING PRACTICE

THE DRYING YARD

SITE SELECTION

The location of a yard site is largely controlled by such necessary considerations as timber supply and transportation facilities, and generally climatic conditions have little weight. But when these larger considerations have determined the approximate location, then elevation, topography, surface, and drainage should be taken into account in the choice of the actual site. (Pl. 1.)

Marked differences in elevation, even within a rather limited area, make a difference in the extremes of temperature and humidity.

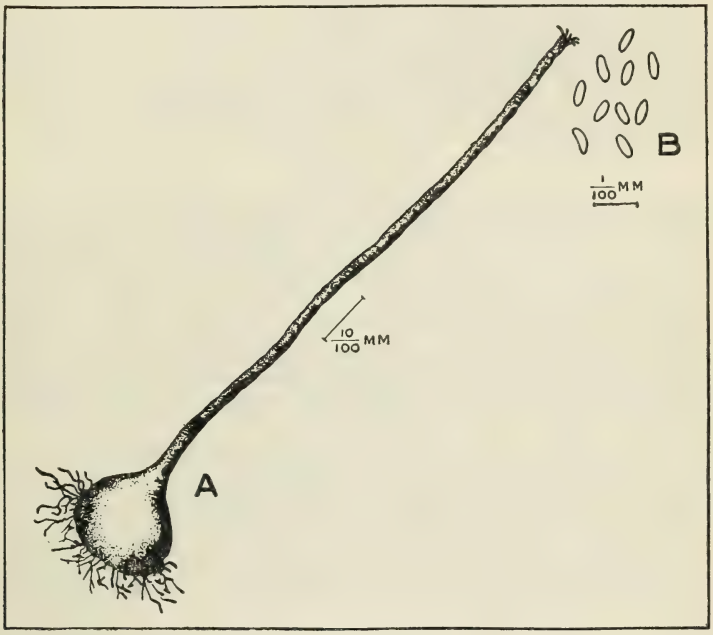


FIG. 4.—A, the flask-shaped fruiting body of a blue-stain fungus; B, the minute spores ejected from the tip of the fruiting body, and capable of germinating and starting new infections

Topographical features may materially influence the direction and volume of wind movement as well as the amount of direct sunlight which reaches the yard each day, thus playing a very direct part in drying and also exerting an indirect influence on the rapidity with which the soil dries after rains, the snow melts, and the fog clears away.

The slope and regularity of the ground have an important bearing on surface drainage, on proper construction of pile foundations, and on yard transportation. Poor drainage in the lumber yard is definitely a contributory cause of slow drying, particularly in those periods of the year when more rapid drying is most desirable. It may also hinder transportation and other operations in the yard.

The relation of drainage to effective air seasoning is seldom fully recognized. It is the one natural influence subject to absolute control in existing yards and should receive more attention than is usually accorded it.

YARD LAYOUT

Economy or yard space is, of course, a consideration in laying out the drying yard. It is of greatest importance where land values are high or the area available is actually limited in extent. But economy in this respect is generally questionable if serious seasoning defects result. The most rapid drying consistent with the least depreciation of stock is a primary objective of air seasoning.

The layout of the drying yard should therefore depend in a large measure upon the climatic conditions to be encountered. If temperature, humidity, and wind movement are of such character that slow drying may be expected, the yard should be laid out in a much more open manner than would be necessary with rapid drying. In the fog belt of the Douglas fir region, for example, congestion in the drying yard is a more serious difficulty than in the San Joaquin Valley of California.

MAIN ALLEYS

In planning the drying yard the direction and width of the main alleys should first be decided. These alleys must accommodate all the transportation and handling of lumber in the yard, of course, but, if seasoning is to be properly done, they must also function as well-defined channels of air circulation in the yard and of sunlight to the front of the lumber piles. The operating functions must be considered, but it is the drying functions that are of major importance. Only too often convenience in handling is given undue weight in the yard plans.

Of the three things that may influence the layout of the main alleys, slope may be of special importance because it affects considerably the transportation system, particularly that of the gravity type. But direction of prevailing winds and the desirability of maximum direct sunlight against the piles and on the alley floor bear directly on the seasoning problem and should be of chief concern.

The desirability of admitting heat from the sun's rays to as much of the pile as possible has been emphasized. This can best be accomplished by a north-to-south arrangement, for it permits the direct rays of the sun to strike farther down on the pile, front and back, for a longer period of the day than will an east-to-west arrangement. The transmission of more heat to the sides of the pile in an east-to-west arrangement does not equalize this advantage, because of the narrow spacing inevitable between piles on the same alley. The benefit in north-south alleys is most pronounced in the cooler and wetter months, when it is most needed.

The main alleys offer the best channels for the movement of air currents in the yard. Thus it is apparent that their alignment parallel to the direction of the prevailing winds would be favorable to yard circulation. But in spite of this advantage their location from north to south, irrespective of prevailing wind direction, will probably give the best drying conditions.

Drying conditions surrounding the lumber pile are improved by the north-and-south alley in the seasons of greatest humidity. Snow does not accumulate as rapidly or remain as late in the spring at the front or rear of the piles. Fog is cleared with less delay. Even if the prevailing winds come from the east or west, their effect on yard circulation need not be lost if the narrow spacing between the sides of the piles is made continuous from alley to alley across the entire yard.

Apparently little thought has been given to direction of layout in the construction of most western yards. Both north-south and east-west arrangements are found very generally in the several producing regions. In the building of new plants and the extension of existing yards, the definite merits of north-and-south alleys should be given recognition. The decision as to the direction of the main alleys will of course settle as well the direction of the other openings in the yard.

Main alleys are seldom so narrow as to restrict unduly either lumber handling or the movement of air currents in the yard, and yet the maximum drying benefits from the direct rays of the sun are not to be obtained with a minimum width of less than 16 feet. The width should preferably be 20 feet, especially where drying is naturally slow. Throughout the West, main alleys are commonly 16 to 18 feet wide but range from 12 to 26 feet. (Pl. 2, A.) Strangely, the narrower alleys are usually found in yards where general seasoning conditions would dictate the maximum.

REAR ALLEYS

Rear alleys are sometimes utilized for lumber handling, but their real function is to improve drying conditions. Their effectiveness is dependent, as is that of the main alleys, upon direction and width. In view of the very general necessity for economy of yard space, a width of 12 feet is recommended. However, where rapid drying is sought, rear alleys 16 feet wide are more effective. If an extremely open layout is essential, the rear alleys should bear a greater proportion of the increase in width than the main alleys. The need for surface improvements in the main alley, which must be suitable for transportation, ordinarily prohibits a width of more than 20 feet.

In western softwood yards rear alleys 8 to 12 feet wide are very common, but variations from 2 to 80 feet are found. That the seasoning benefits from adequate spacing are not fully appreciated is evident in the use of narrow rear alleys in some of the locations most unfavorable for drying.

CROSS ALLEYS

Cross alleys, openings at right angles to the main alleys, serve a number of purposes. They reduce the fire hazard, facilitate transportation and general movement about the yard, and influence the air circulation. Local conditions naturally have an important bearing on the interval between cross alleys. An ideal arrangement, which some yards boast, is a cross alley every 200 to 300 feet, although this is not always practicable. In the average yard there should at least be 8 or 10 with a minimum width of 20 feet. Sixty feet is very de-

sirable in the interests of fire protection. The great variation found in existing yards indicates a failure to appreciate the value of cross alleys. Some yards 2,000 feet in length have none.

SPACING BETWEEN PILES

The necessity for proper spacing between the piles on the same alley can not be emphasized too forcibly. The primary purpose of these openings is to aid air circulation, not only to supplement the alleys in building up general air currents in the yard, but also to exert a very definite effect on the horizontal circulation in the lumber pile. The front and usually the rear of a pile, because of the location of the crossers, present an almost solid face. The sides of the pile offer the only easy inlet and outlet for downward air currents. A very definite circulation along the sides of the pile is essential to effective drying. To obtain this, a spacing of at least 3 feet and preferably 4 feet should be used. Where local air movement is sluggish, a spacing of 5 or 6 feet may be justified. A secondary benefit from adequate pile spacing is that as the width is increased the direct rays of the sun strike farther along the sides of the pile during a greater part of the day.

If the relation of adequate pile spacing to the air-seasoning process is appreciated by the lumber industry of the West, it is not apparent in present practice. Although a maximum spacing of 6 feet is occasionally used, the average is about 2 feet, and many yards have still narrower spacing. In certain yards where slow drying and the resultant difficulties exist, the most effective single improvement would be to widen materially the spacing between the sides of the piles.

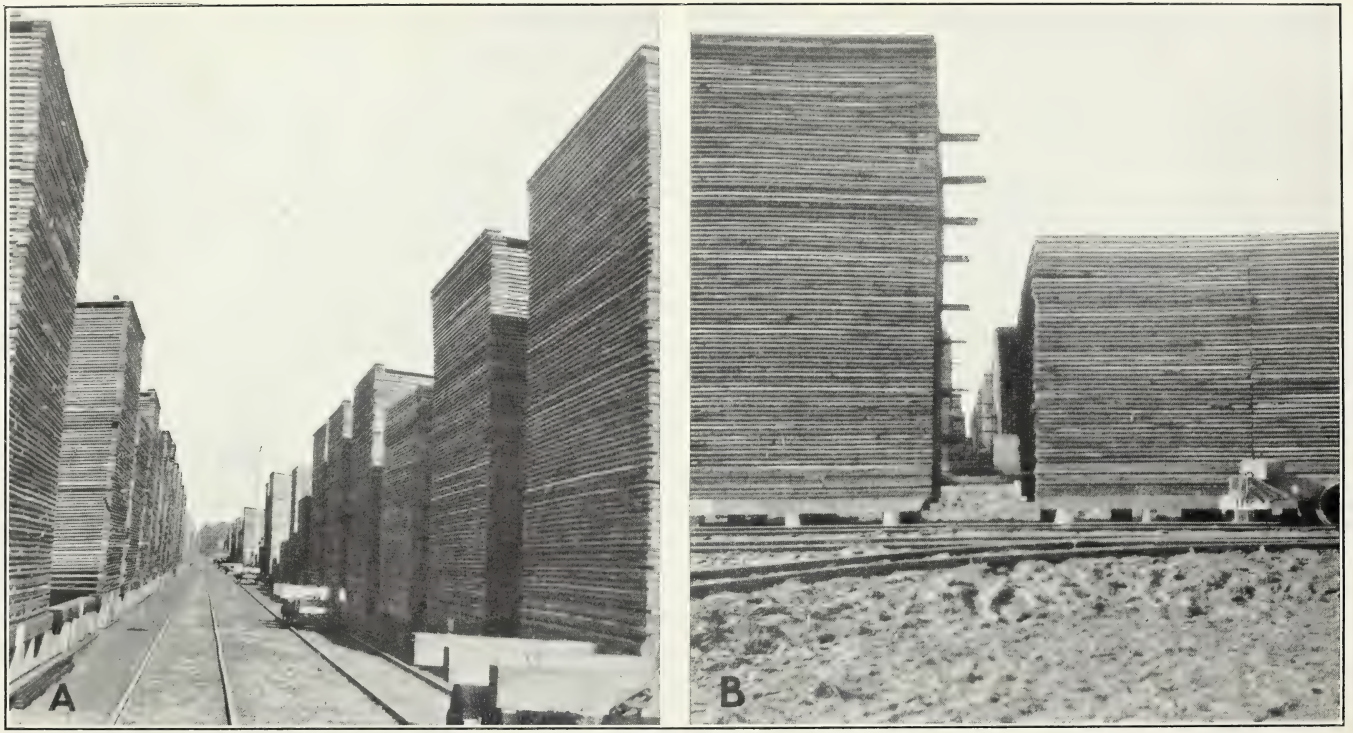
In order to obtain the maximum benefit from local wind currents, the openings between the sides of the piles should be continuous from alley to alley, providing unbroken channels from one side of the yard to the other. (Pl. 2, B.) This arrangement is especially desirable where the prevailing winds come from the east or west and the main alleys are laid out from north to south. To effect this arrangement it is necessary to segregate stock lengths in the yard by blocks rather than by alleys unless a uniform width of pile foundation is used throughout.

The advantage of this type of layout is recognized to some extent. It is commonly found in the California pine region and occasionally in the Inland Empire and Douglas fir regions. Oddly, in the redwood region, where climatic conditions make for generally slow drying, this arrangement is not in use.

TRAMS

The use of trams in the drying yard should be discussed in connection with layout, for where the ground is very uneven trams may seem desirable for facilitating yard transportation. Also, higher piles can be erected by hand in tram yards. But the hindrances to seasoning inherent in trams may more than offset their benefits. Air movement below the level of the tramways is seriously retarded, just where it is of greatest importance in order to maintain a positive

A WESTERN AIR-SEASONING YARD



GOOD PRACTICE IN AIR SEASONING OF SOFTWOOD LUMBER

A.—A typical main alley in well-kept Douglas fir yard
B.—Excellent spacing between piles at the sides

horizontal circulation in the lower part of the pile. Tramways also prevent the direct sunlight from reaching the lower part of the pile.

Naturally, the rate of drying below the tram level is greatly affected. Actual yard tests under ordinary conditions have shown that stock below the tramway requires 40 per cent more time to dry down to a given moisture content than stock above the tramway. Also, during a given period, stock below the tramway will reach a moisture content of only 18 per cent while the stock higher up is coming down to a moisture content of 11 per cent. It follows that, in drying pine, stain development is much greater below the tram. Such differences between the upper and lower part of the pile are very much greater than in piles of the same height where trams are not used.

Trams are going into disuse gradually but surely. A considerable number of tram yards are still found in the California pine region, but only an occasional one is found in the Douglas fir region; there are few in the Inland Empire and in the redwood region. Where trams are in use, their effect on drying should be definitely recognized and circulation below the tramway assisted as far as possible by modifying the arrangement of the lower part of the pile.

PILE FOUNDATIONS

The foundation upon which the pile is erected should be so constructed as to perform several very definite functions, the least of which are the designation of the location of the pile and the keeping of stock from direct contact with the soil, for almost any kind of bottom will do these things. Horizontal alignment of the lumber, to prevent deformation and even breakage in the lower part of the pile, depends largely upon the foundation. Construction must therefore be such as to prevent appreciable sag at any point. To provide adequate bearing surface for the stock, a stringer must be placed across the width of the foundation for each tier of crossers to be used in piling. But the function of vital importance to seasoning, and the one generally disregarded, is the facilitating of proper circulation.

Adequate clearance between the ground and the foundation stringers is necessary for both horizontal and vertical circulation. It is absolutely necessary for positive horizontal circulation at or near the bottom of the pile, by which means the moist air dropping to the bottom of the pile is removed. Not only does such construction provide for the flow of moist air from beneath the pile, but also it affords access to wind currents from the main and rear alleys. These currents find little if any ingress at the front and back of the pile because of the crossers.

TYPES OF FOUNDATION AND STRUCTURE

Plates 3 and 4, illustrating the standard types of the better foundations now used in the West, show the basis for recommendations. The construction shown in Plate 3, A is an example of the unit pier and stringer bottom. Plate 3, B shows the common pier and stringer foundation of the continuous type. Both of these are excellent if the ground is properly prepared and heavy mud sills are used. The

unit type is cheaper to construct, more easily kept in repair, and, if the yard is properly laid out, assures adequate and uniform spacing of the piles. It is generally more flexible than the continuous type, as it can easily be changed to accommodate different lengths of stock and to make repairs.

Another style of foundation, which has much merit, is illustrated by Plate 4, A. It is the most rigid type in use and definitely precludes any variations in the spacing between the sides of the piles when once the yard is built. One admirable feature is that the stringers upon which the lumber is piled are not attached to the permanent part of the structure, but can be moved to support stock of different lengths. This type assures a firm bearing at each tier of crossers. Obviously, much better original material and a higher labor cost are required than for the other two types. Also, because of the cross and lengthwise bracing, more obstruction is offered to air movement under the pile. In Plate 4, B is shown a good type of pile-bent foundation, necessary where the yard is located over water.

These examples of construction are above the average for the western softwood territory generally. Very poor foundation construction is too often found. Local conditions will affect the choice of structure, but whatever type is preferred the chief functions of the foundation should always be clearly kept in mind. The use of concrete piers or treated wood supports for the foundation stringers has much merit. Moist air and damp soil beneath the lumber pile are naturally favorable to decay, and untreated members in contact with the soil require constant replacement if poor alignment is to be avoided.

NUMBER OF FOUNDATION STRINGERS

In general, a stringer should be provided for each tier of crossers in the piled stock. The number of crossers that should be used to each course of the lumber will be covered later under "Pile construction," but as a broad principle it may be stated here that for western softwoods the maximum distance between supports should be 8 feet. In order that different stock lengths may be provided for, the type of bottom shown in Plate 4, A is very desirable as being the most flexible in this respect. With other types, special foundation must be provided for different length piles. Plate 4, C illustrates the effect of insufficient bearing.

HEIGHT OF FOUNDATION

Actual study has shown that adequate unobstructed clearance beneath the lumber pile is a basic factor in effective air seasoning. Controlled yard tests have demonstrated that as the foundation height is increased the inherent lag in drying between vertical sections of the pile is decreased; final moisture content of the stock is more uniform throughout the pile and during a given period will reach a lower average; and, in pine, depreciation from stain is reduced, particularly in the lower third of the pile where blue-stain development is ordinarily greatest. In drying redwood, a difference of 12 inches in the rear height of the foundation resulted in a final average moisture content of 18 per cent for the stock on the higher bottom and of 12 per cent for that on the lower. Stock in the higher

pile reached an average moisture content of 23 per cent in 128 days, whereas that is the lower pile required 191 days, or a period half again as long, to come down to 23 per cent.

Increase in the foundation height is justified up to the point where the loss of yard space and additional cost of piling may offset the very real seasoning advantages mentioned. The minimum clearance below the stringers upon which the stock rests should be 12 inches. This means ordinarily a foundation height of 18 inches at the rear, and proportionately more at the front if the usual slope is built into the structure. When the influence of an active horizontal circulation under the pile is correlated with the local seasoning problem, a greater clearance may be found profitable. In yards where the rate of drying is exceptionally slow, an 18-inch rear clearance may be the most effective and cheapest remedy, returning real dividends on the added cost. Further, this potent aid to fast drying can never be the cause of depreciation from excessive drying, since it affects primarily only the lower section of the pile.

In practice to-day the average rear height of foundations is between 8 and 12 inches, which at best means a clearance under the pile of about 6 inches. Practice varies, however, from a 4-inch height—simply stringers laid on the ground—to 24 inches, or a rear clearance of 18 inches. Plate 5, A shows an only too common type of foundation. With such construction, wind currents along the alleys exert but little effect upon the circulation under the pile. It is not difficult to appreciate how damp and sluggish the air must be in the lower portion of these piles and beneath them.

SLOPE OF FOUNDATION

The slope in the foundation from front to rear is many times given more thought than other more essential considerations. A slope of from 0.5 to 1 inch per foot of length is commonly used. This, if carried up in part at least with the pile, undoubtedly makes it easier to give adequate pitch to the roof and consequently to secure good run-off. Also, water leaking into the pile will drain off more rapidly. With the piles adequately roofed, however, slope becomes of minor importance, except as it may be of some little mechanical assistance in constructing the pile. If slope is not built into the foundations, it may be obtained by using extra crossers at the front and center, as illustrated in Plate 3, A.

DIRECTION OF FOUNDATIONS

Almost without exception in the West, lumber is piled perpendicularly to the alleys, and foundations are constructed accordingly. Piling parallel to the alleys has sometimes been considered to be a superior means of seasoning, but this claim was not substantiated when actual comparisons of the two methods were made. Two very apparent objections to parallel piling are, (1) that the run-off from the roof falls in the narrow spacing between piles, where the soil necessarily dries out more slowly than in the wider rear alleys; and (2) that the cost of handling stock by this method is greater than by perpendicular piling.

GENERAL YARD CONDITIONS

Plates 2, A and 4, C offer a remarkable contrast of sanitary conditions as actually found in the West. There is much room for improvement in most of the yards. No yards have been seen where recommendations for sanitation have been taken too literally or overdone. The cleanliness of a yard is largely a matter of habit with the workmen, and therefore the prevention of débris accumulation should be definitely insisted upon. Incidentally, cleanliness and order about the yard inevitably inspire the employees with more pride in their work and result in greater efficiency.

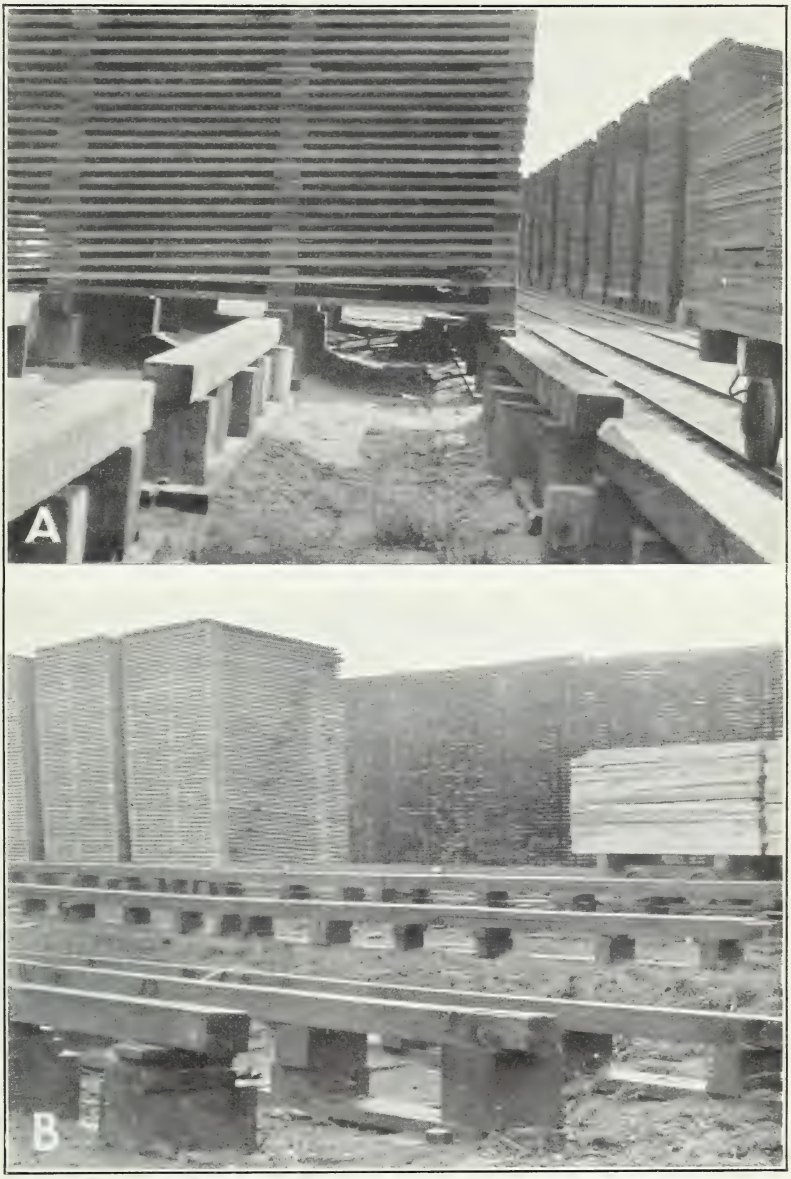
Weeds and other vegetation in the drying yard not only retard air movement under the piles but also decrease the rate at which the ground dries after rains. How unfavorable both of these effects may be can be visualized by referring to Plate 5, B, particularly if this view is compared with the admirable conditions shown in Plate 2, A. Excessive vegetative growth in the yard should be prevented, and this may be accomplished in a number of ways. Chemical weed killers or sheep grazing may supplement or entirely do away with the more costly and less effective use of the scythe.

Methods of handling and sorting crossers not in use may also have an important bearing on seasoning. It is not unusual to find the circulation under a green lumber pile entirely or partially blocked by crossers and roof boards which have been thrown or stacked on the ground against the front, rear, or sides of the foundation. Plate 4, A illustrates a practice which greatly reduces this evil. The extension at the front of the foundation provides a convenient place for roof boards, and cross pieces between the sides of adjacent foundations afford similar storage for crossers. With such practice, none of this material left after the erection of a new pile will be lying about to stop circulation beneath the foundation. Methods of this kind tend also to prevent breakage and warping and to keep crossers off the ground and consequently drier. Dry crossers are less liable to become infected with blue stain and to transmit the stain to the stock piled upon them.

Yard sanitation is a very practical measure in the control of blue stain. It has already been stated that the principal source of blue-stain infection is in the spores produced when the fungi have developed sufficiently on piled stock or other suitable material. Incipient infection of decay is caused in the same manner. Preventive measures are quite logically aimed at attempting to avoid the conditions favorable to growth of blue stain; but the liability of infection should also be reduced as far as practicable. Mill refuse should never be placed in the yard, and broken boards and like débris should not be allowed to accumulate. Such material, in addition to increasing the fire risk, is soon infected with stain and decay organisms and rapidly becomes a new source of infection.

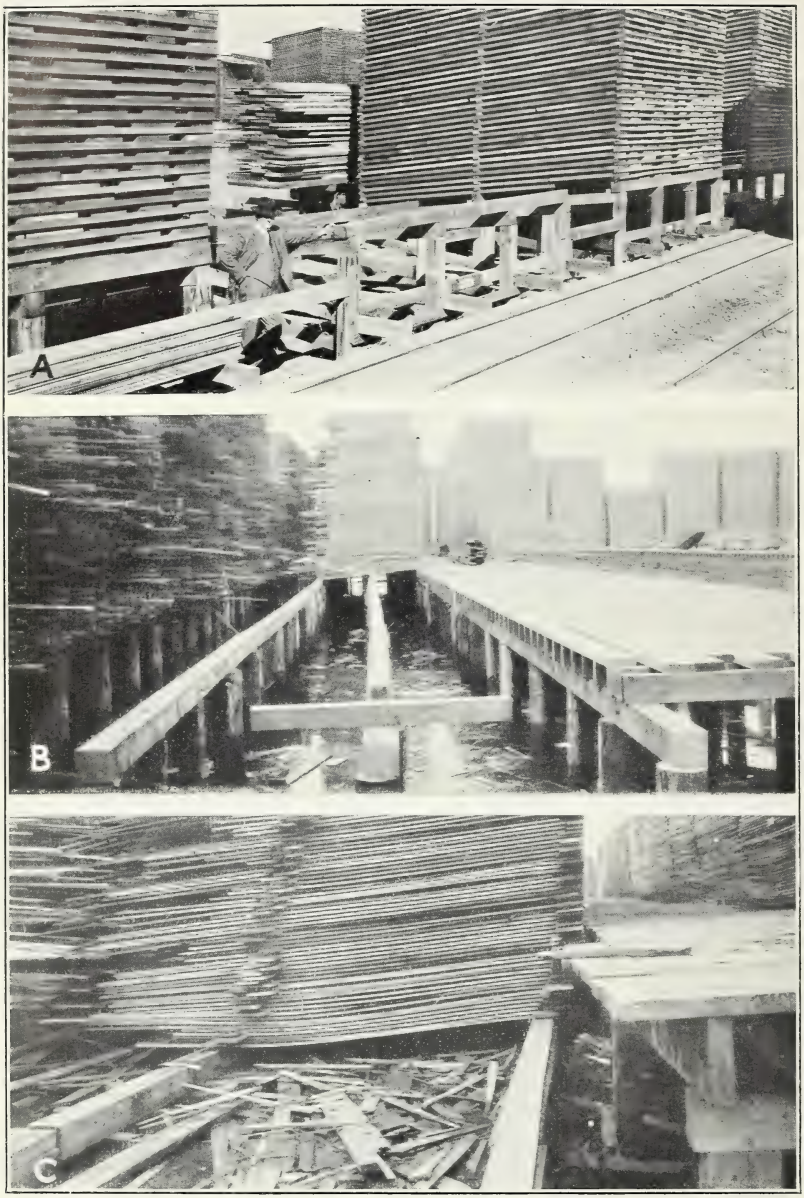
YARD TRANSPORTATION

As would naturally be expected over such a large territory as the western lumber-producing region, numerous and varied methods for the movement of lumber to and from the drying yard are employed. Transportation over a track system by either motors or horses is



TWO VERY SATISFACTORY TYPES OF FOUNDATION

A.—The unit pier and stringer foundation
B.—Continuous pier and stringer



GOOD AND BAD FOUNDATIONS

A.—A well-constructed rigid type
B.—Pile-bent foundation over water
C.—A poor foundation in an insanitary yard

common, particularly in yards of large area. Both gas and electric surface carriers, which actually carry the lumber rather than merely haul it, are gaining in popularity. Auto trucks, especially constructed to permit automatic loading at the green chain and unloading upon scaffolds or sawhorses at destination are also used. Wagons and dollies propelled by tractors or horses are still employed to a considerable extent, and a new development, rather limited as yet, is the use of monorails or cranes in the yard.

Such a wide range of methods is in some measure attributable to differences in local conditions. Topography, surface conditions, size and layout of the yard, species and sizes of stock, and similar elements may have an influence upon the type of transportation selected. These must necessarily be correlated with such factors as cost of actual moving operations, effect of the transportation system upon the efficiency of related yard operations, and influence of the system upon seasoning conditions. It is not within the scope of this bulletin to attempt a full discussion of the many and complicated phases of efficient yard transportation. However, some reference to its relation to other yard operations and to seasoning conditions is pertinent.

The relation to other yard operations can be well illustrated by some comparisons between two very different types of transportation. The use of wagons and horses in the yard is a most inflexible method. Stock must immediately be unloaded by dropping it on the ground. If not in the proper location for piling, it is difficult and costly to move. When hand piled, one-third to one-half of the lumber in each pile must be handled twice, once on to scaffolds and once on to the pile. Despite care in unloading, the stock comes in contact with dust and mud. During the dry season dust raised by the teams penetrates the piles. Dirt and grit thus accumulating on the lumber not only increase the liability of blue-stain infection but later have an appreciable effect on planer knives.

The track system, on the other hand, is a most flexible method of transportation. Stock can be held on the trucks until piled, allowing temporary storage, when necessary, in any part of the yard and avoiding congested working conditions in the alleys. Stored trucks can later be moved easily to the final location. Since the loads are high and conveniently moved, and all piling can be done directly from the trucks, work on one high and one low pile can be carried on at the same time. The stock never comes in contact with the ground; dust is of little consequence in tracked yards; and the lumber handlers lose no time waiting for teamsters.

The movement of lumber to and from the drying yard is often considered merely as a physical operation, without its being realized that the transportation method employed may materially influence seasoning. The direction of the yard alleys may be fixed by the transportation system rather than by seasoning considerations. Transportation by certain methods can very materially add to depreciation losses through incidental breakage and damage. The influence of these methods upon the height of hand piling may result in congested yard conditions, in low foundations, and poor piling practice. Some methods of transportation can definitely increase the liability of stain infection in pine yards.

SEGREGATION OF STOCK FOR PILING

The sorting of green lumber by species, grades, and sizes follows to some extent a general standard in each region. It is of necessity, however, primarily an individual plant problem because of the many considerations involved. Quantity production of different items, sorting and yarding facilities available, trade customs and demands, and requirements for proper seasoning must each be considered in its proper relation to the others. Of these, the items produced in quantity and the yard facilities ordinarily vary most as between plants. Seasoning requirements, although of real moment, are rarely given their proper weight in the choice of a sorting practice.

IMPORTANCE IN AIR SEASONING

Proper stock segregation is an essential element of effective air-seasoning practice. Individual species usually have distinct drying requirements and accordingly should be piled separately. This is also largely true for different grades of the same wood, although some of these may be segregated for drying by natural groups. The soundness of such methods can best be demonstrated by a specific example.

Western yellow pine and white fir, species commonly produced at the same plant, need very different seasoning treatment. Western yellow pine is more susceptible to blue-stain depreciation than any other western species and therefore requires a method of pile construction which will favor fast drying and thus tend to retard development of the stain organism. White fir, on the other hand, is not subject to stain depreciation but is much more liable to check if seasoned rapidly. In the select grades of western yellow pine sapwood is present to a greater extent than in the common grades, and the select grades are therefore more susceptible to blue stain. The common grades, however, because of greater liability to knot defects, call for slower drying.

Segregation of stock by thickness is almost a necessity because of the difficulties incident to piling the unsorted lumber. With lumber of random thickness it is practically impossible to obtain an even bearing surface for the crossers and thus to avoid warped stock and poor horizontal circulation. Another serious objection is that the drying period for the entire pile is dependent upon the time required by the thickest pieces. For example, 4/4 stock requires but 50 to 80 per cent of the time necessary for 8/4 stock to reach the air-dry condition, the ratio varying with different species, grades, seasons of years, and general drying conditions.

For thorough seasoning, width segregation is of real value. The vertical air circulation in the lumber pile should be assisted in every way practicable by the method of pile construction. Unobstructed vertical channels throughout the width of the pile are therefore very desirable, and it is only by piling separate widths that uniform vertical flues extending from top to bottom of the pile between each tier of boards are possible.

Segregated lengths are also an advantage in piling for air seasoning. With each length separated it is more readily possible to em-

ploy the box type of piling, which, as will be pointed out in the discussion of pile construction, is considered extremely desirable. Random lengths can be box-piled but only with more difficulty.

CURRENT PRACTICE

Although regional standards differ and the problem is definitely affected by local plant conditions, the principles followed rather generally in the West are of interest. Species are almost always segregated. It is also fairly standard practice to separate grades—at least by groups, such as selects, shops, and common. Common particularly is generally sorted by individual grades. Each thickness is piled by itself. Inch selects are commonly separated by widths, while thicker selects and most shop are handled in random widths. No. 3 and better common is ordinarily segregated by width, and the lower grades of common are occasionally sorted in that manner. The sorting of lengths is the practice least consistently followed. At the more progressive plants, however, particularly those of large daily production, a great deal of lumber is piled in separate lengths. Shop lumber is very generally handled in random lengths.

Thick select and shop lumber is piled random width primarily because of trade requirements, although volume production is also a factor at some plants. The handling of the lower grades of common in mixed widths is due to the low value of the product and to the customary method of selling in all-width lots. The less desirable size segregation of other stock is usually the result of inadequate sorting facilities or small production.

In spite of limitations of space and production, a greater amount of stock can be piled in separate widths and lengths if less segregating of grades is done. Although the piling of separate grades is often desirable from an operating standpoint, that is not always rightly the major consideration. Grade and size segregation should be balanced one against the other in the light of the seasoning as well as the operating advantages. Too often the more tangible operating advantage is allowed to predominate in the decision and the actual dollars and cents savings from improved seasoning practice are overlooked merely because they are less easily recognized.

PILE CONSTRUCTION

MAJOR CONSIDERATIONS

Two distinct major considerations are involved in the logical development of methods of pile construction—losses to be avoided through proper seasoning and economy in piling cost and yard space. Here again intangibles and tangibles are in conflict, and the advantages of one must be weighed against those of the other. It is because of the lack of a sure basis for judgment in such decisions that true efficiency in air seasoning is so generally defeated.

A reduction in operating expense is apparent not only upon inception but with each monthly and annual cost statement. The depreciation losses that result directly from poor seasoning conditions are easily overlooked and are rarely accurately inventoried. And yet

a reasonable addition to the piling cost may readily pay for itself many times over by a considerable saving effected through reduction of degrade. More rapid stock turnover, lower shipping weights, and the customer's appreciation of low, uniform moisture content are also actual returns from what may appear to be more costly piling methods.

Of course, climatic conditions must serve as a guide to piling practice. To illustrate, during the active drying season in the Inland Empire hot days with extremely low humidity are common. In the redwood region a greater humidity is the rule. The method of pile construction used in the Inland Empire must anticipate depreciation from checking to a greater degree than would be needful in the redwood region. Again, high piles are more practicable in a warm climate than in one less favorable to drying, for in the warm climate the amount of direct sunlight which reaches the lumber pile is less important.

The layout of the drying yard also bears on the methods of piling to be followed. Stain development is a more acute problem of pile construction in a crowded yard than in a less congested one. If trams are employed, slow drying and the incident evils occur in the stock below the tram level. Under such conditions more expensive pile construction is justified to build up the air circulation in the lower part of the pile.

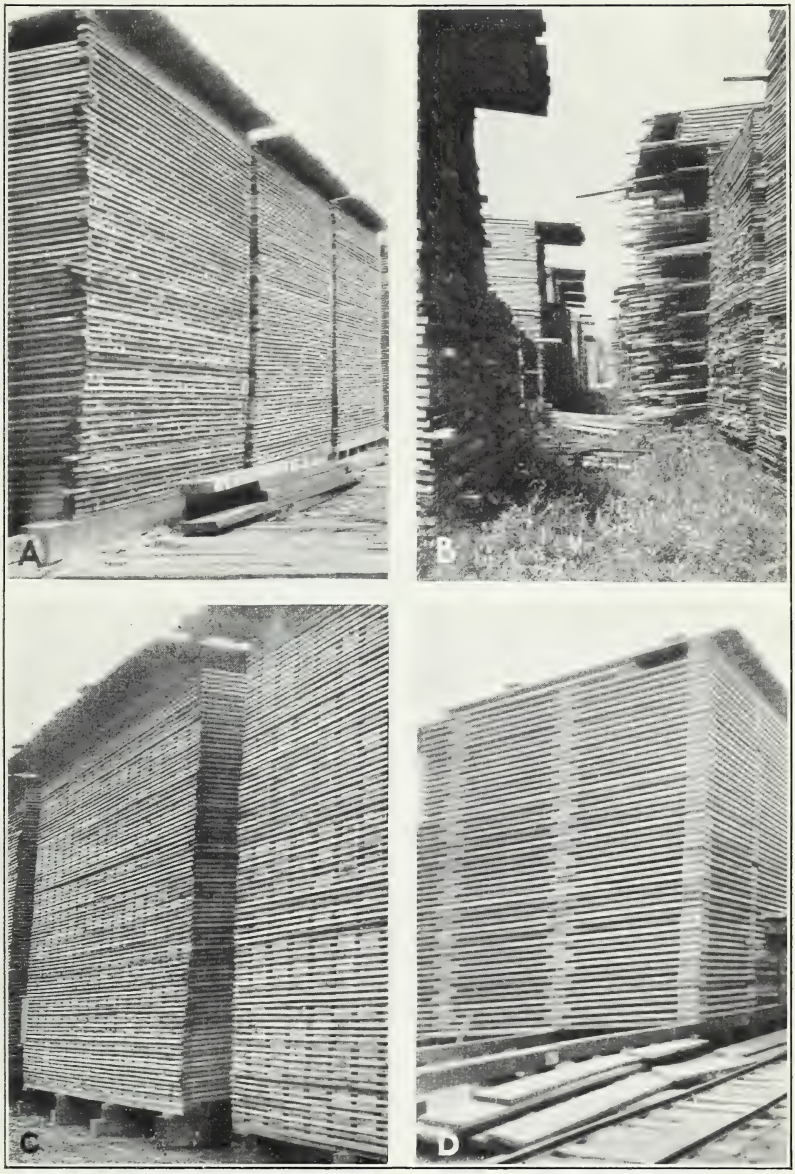
It has been pointed out that, because of their different degrees of susceptibility to defect, different species need individual treatment. Similarly, the several grade groups of the same wood may require different pile construction, not only because of differences in defect development but also because the greater the value of the product the greater the expense justified to prevent depreciation. Thickness of the stock, since it affects the rate of seasoning and liability of depreciation, also necessitates adaptations in piling.

TYPE AND SIZE OF PILES

Three general types of lumber piles are used in western softwood yards. The so-called box pile is commonly employed in all of the producing region. Plate 5, C, is a rear view of excellent box piles. What may be termed a "modified box" pile is shown in Plate 5, D. This type is used very generally in the Douglas fir region but is not common elsewhere. A third type, and one that is found in too many yards in each region, may be called the "random length" pile. This method of piling, which is illustrated in Plate 6, A, is obviously an improper one for efficient air seasoning.

THE BOX PILE

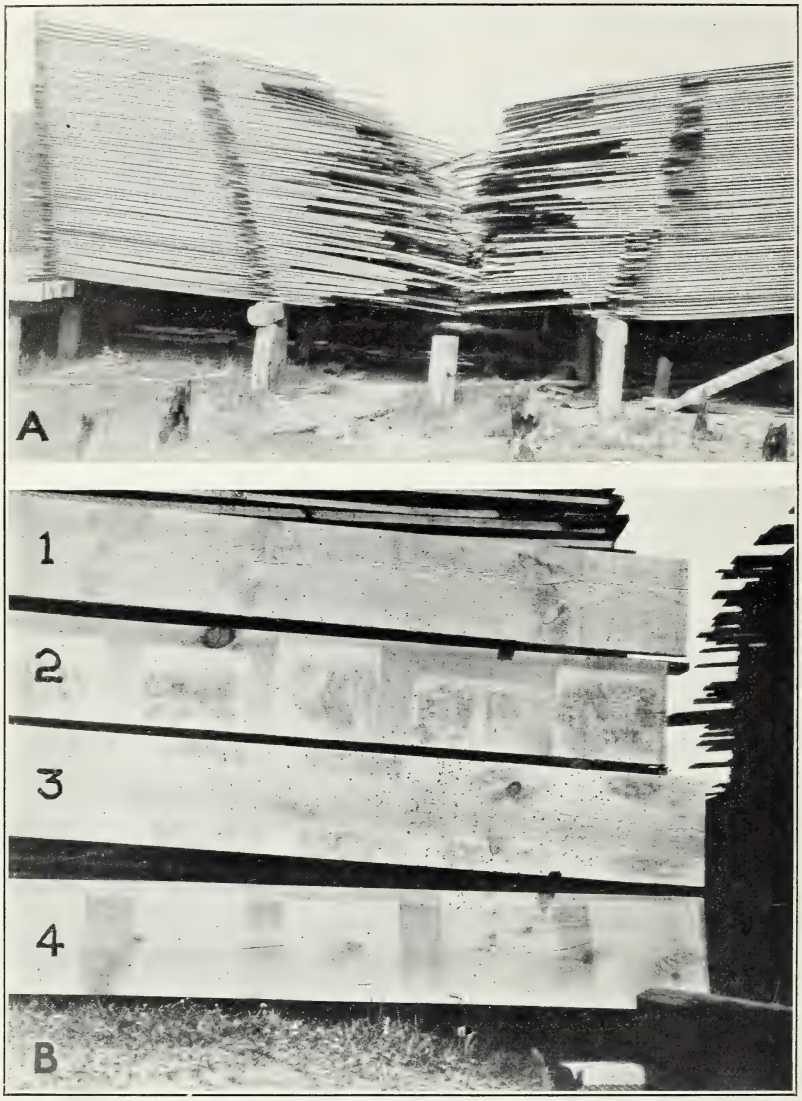
Box piling is a method that permits the ends of the stock to bear upon the front and rear crossers, which should in turn bear directly upon the front and rear foundation stringers. Expressed another way, the stock does not overhang the rear crosser. This method has real advantages. Both segregated and random-length lumber can be piled in this manner. Stock is uniformly protected from the weather and all parts of the lumber are given adequate bearing sur-



TYPES OF FOUNDATIONS AND OF PILING

A and B illustrate foundations and yard conditions that should never be permitted in softwood yards

C and D show types of piling that are very satisfactory when carefully done. C.—Box piles, rear view. D.—Modified box piling



A.—The random-length type of pile
B.—Common pile stock crossers 1×12 inches, 16 feet long. Season check shows in Nos. 1 and 4. Crosser-stain has developed in Nos. 2 and 3

face. Considering all kinds of stock and all kinds of weather conditions, the box pile will undoubtedly give best seasoning results.

Random-length lumber is usually box piled by placing one end of the short pieces alternately on the front and rear crosser. This practice tends to allow the crossers to "weave" somewhat and may result in considerable depreciation of the crossers and to some extent of the stock. This may, however, be avoided with little, if any, additional expense. The usual run of even-width stock, 10 to 16 feet in length, contains at least 50 per cent of the latter length. By carrying up the two outside tiers of boards and from three to five interior ones, depending upon the width of the stock, with 16-foot boards, the rear crossers are given adequate bearing surface even though all of the shorter pieces be placed flush with the front of the pile. This permits a good box pile, but lengths longer than 16 feet must be piled separately.

The criticism of the box pile is sometimes made that there is greater liability of end checking than if 2 feet or more of the stock overhangs the rear crosser. The theory is that this overhang allows an equalization of the stresses caused by the uneven shrinkage which results from the more rapid drying of the end grain. But with proper methods of box piling end checking need not be appreciable. If the front and rear crossers are permitted to project beyond the ends of the stock, these ends are shaded from direct sunlight and the rate of end drying is reduced. Narrow crossers should also be used to reduce the area of the stock not exposed to the air. With these methods, which are covered fully in the later discussion of crossers, the end checking incident to box piling is not to be compared with the depreciation which occurs in the overhanging ends of the random-length pile. Such a conclusion is substantiated by the opinion of representative lumbermen, observation at numerous plants, and the results of specific studies.

THE MODIFIED BOX PILE

The modified box pile is limited in use to separate-length stock and differs from the box type in one other particular. The rear crosser is placed 18 to 24 inches back from the ends of the stock. With the rear of the pile presenting a solid regular face and a maximum overhang of 2 feet, this type is far superior to the random-length pile. It offers greater protection to the overhanging ends from the weather extremes and does not permit as much deformation. The liability to end checking is probably less than in careless box piling where wide stock is crossed with itself and the crossers do not project beyond the ends of stock. The modified box type is well adapted to seasoning even-length stock in regions where low humidities and excessive drying do not occur at any season of the year. This is particularly true with stock thicker than 4/4 and with the lower grades of common in which a certain amount of checking and slight deformation is permitted.

THE RANDOM-LENGTH PILE

There is entirely too much use made of the random-length pile in the western softwood regions. The varied-length overhang at the

rear of the pile (pl. 6, A) can only result in depreciation of one kind or another. Exposed to the direct rays of the sun and the other weather elements the overhanging ends are subjected not only to excessively rapid drying but usually to alternate wettings and dryings. Also, there are no supports to hold these ends in alignment during seasoning. As a consequence, end checks, splits, warp, twist, and cup occur. Use of this type of pile can be justified only with products of very low value and which permit large amounts of the defects mentioned. Such stock would include No. 5 boards, culls, shims, and similar material.

PILE WIDTH

Width of the lumber pile is ordinarily determined by other details than a consideration of its effect upon drying conditions. The width of foundations, the method of crossing the stock, and the plan of stock segregation usually influence this matter. If unit foundations are 16 feet wide, piles are this width. With separate provisions for each length of stock, the foundations are ordinarily square, and pile widths correspond. Square piles are also used where stock crossers are employed on separate-length stock. With random lengths, the longest piece often controls the width of the pile. When 18-foot and longer stock is piled separately, however, the piles are commonly only 8 to 12 feet wide, owing to the relatively small production of such sizes and the necessity for smaller piles.

Although varying greatly at individual plants, pile widths as a rule follow a general standard in each region. The unit foundation is common in the California pine territory, and piles are usually 16 feet wide. This is true to some extent in the Inland Empire, but there the square pile is employed most frequently. Although pile bottoms in the redwood region are generally of the continuous type, pile widths are mostly 16 feet. In the Douglas fir region the square pile is the standard.

Despite the fact that seasoning considerations are given little weight in fixing the pile width, this element of pile construction has an important bearing on drying. Stock at the center of the pile has been found to dry much more slowly than that near the sides. Naturally this lag becomes smaller as the top of the pile is approached and is less pronounced during the active drying season. This variation is clearly shown by Figure 1, which pictures actual drying in a representative pile 16 feet in width.

With Inland Empire conditions, the average lag in drying between the center and the sides of the pile is approximately one month in the lower third of the pile and two weeks in the upper third. Naturally, as the width of the pile is decreased this differential becomes smaller, and the average drying period for the pile is shorter. Actual yard tests with sinker redwood stock substantiate this nicely. In piles 8 feet wide an average moisture content of 19 per cent was reached in 136 days. Stock in piles 16 feet wide, put up at the same time and under exactly the same conditions, came down only to an average moisture content of 36 per cent during the same period.

The conditions determining the pile width in actual yard practice are ordinarily of a fixed nature and accordingly difficult and costly to

change. However, if slow drying is a serious problem, reduction in the width of the piles must be considered, since it is a very definite remedy for such a condition. But with the more usual situation, sluggish drying can be avoided by other and less troublesome modifications in pile construction. As a general proposition square piles are most desirable for stock 10 to 16 feet in length. Lumber 18 feet and longer should be seasoned in piles not over 16 feet in width. Here, not only is the rate of drying involved, but this class of stock is commonly produced in such small volume that large piles would be kept open too long.

PILE HEIGHTS

Height of piles probably averages 14 to 18 feet, or 80 to 100 courses of inch lumber, fairly generally throughout the western country, although higher and lower piles are customary in certain districts. Hand piling is limited to about 100 courses in tracked yards and to 80 courses where lumber is piled from the ground. Above these heights machine pilers or other mechanical methods are necessary. Ordinarily, when all factors are considered, a maximum pile height of about 18 feet, or 100 courses of inch lumber, is most desirable.

It is true that higher piles are more economical of yard space but very definite disadvantages must be admitted. Average cost of piling is increased, and a larger depreciation from splitting and breakage may occur. Another very important objection is the bad effect of high piles, as already noted, in shading the lower sections of the piles and also in increasing the difference in rate of drying between the top and bottom of the pile. It may be contended that higher piles permit more stock to season under the more favorable conditions that prevail in the upper sections, but there is a fallacy in this general assumption. Although in a single high pile in the yard an increased proportion of the stock would probably be benefited; in a yard made up of high piles such an advantage would not be found. The unfavorable drying conditions both within and adjacent to the piles would not only be intensified, but their general level would be raised throughout the yard. With the differential between the rates of drying at top and bottom increased, the time required to bring all stock to desired moisture content would not be shortened, and the liability of depreciation from shrinkage defects would be greater, at least during certain periods of the year.

PILE PITCH

Lumber piles are commonly constructed with a pitch or an incline toward the alley which results in a gradually accumulating overhang at the front of the pile. Usually this is slight, but it occasionally averages an inch to each foot of height. This pitch, which allows the drip from the front stickers to fall clear of the pile instead of draining into it, is of much less importance where real roof protection is provided, permitting plenty of overhang at the front and rear of the pile. A slight incline toward the alley, in effect just enough to guard against a backward pitch, is, however, an advantage in the mechanical operation of piling.

CROSSERS

The crossers, or strips or boards placed between the courses of stock at right angles to the stock to facilitate drying, affect not only the horizontal air circulation in the pile but the horizontal alignment of the stock as well. The method of crossing employed has a far-reaching effect upon general pile construction, upon operating costs, and upon depreciation of both stock and crossers. The crossing or "sticking" of lumber is therefore a matter of utmost importance in air seasoning. Solution of many perplexing drying problems will be found in the adoption of proper methods of crossing.

NUMBER OF LAYERS OF STOCK TO THE COURSE

Western softwood lumber is very largely piled one layer to the course, each layer of stock being separated from those above and below by crossers. Because of its tendency to stain, pine is always piled in this manner. "Larch-fir," or western larch and Douglas fir, which is handled and sold as a single product in the Inland Empire, is, however, very generally piled two layers to the course and sometimes three. In the same region, white fir, cedar, and spruce are occasionally "double-decked." Certain grades of redwood and the white fir of the California pine territory are often dried two layers to the course. Double-decking is also used to a limited extent at some plants in the Douglas fir region.

Apparently the objects in view in double-decking, particularly in the Douglas fir region and to some extent in the others, are primarily to increase the capacity of already congested yards and to facilitate more rapid piling. However, to a considerable degree, the practice of piling more than one layer to the course is prompted by the desire to reduce depreciation from the checking and loosening of knots that occur at times of the year favorable to very rapid drying. Although the average rate of seasoning is cut down by this means and probably some forms of degrade are reduced during very brief periods of the year, this system of piling has very real disadvantages and very largely defeats its own ends.

The drying time is necessarily increased greatly. Uniformly dried stock is out of the question, and the uneven drying of the two faces causes serious depreciation from checking and cupping, both during and after seasoning. Careful tests have been made to determine the relative amounts of degrade resulting when the single-layer method and the double-layer method were used. In white fir, double-decking resulted in a 75 per cent greater depreciation than that from single piling—almost entirely due to cup and check. Further, double-decking produced, for the same drying period, a materially higher moisture content. As might be expected, the difference in degrade is not so pronounced with stock 8 inches or less in width.

Although it must be granted that the seasonal piling of certain woods by the multiple system may at times actually have some merit, any unforeseen contradiction of weather conditions, such as a late wet spring followed by an early dry season, very often precludes the success anticipated. Everything considered, excessively rapid drying can be avoided more effectively by other changes in pile

construction productive not only of slower but of more uniform drying. These include narrower spacing between boards, thinner stickers, and other methods to be discussed later.

FLAT-PILED AND EDGE-PILED STOCK

With but rare exception, all stock is flat piled. In an occasional yard 2 by 4 dimension is edge piled with the purpose of reducing the likelihood of bowed stock, a material objection in this item. Inasmuch as both methods afford exactly the same bearing, top and bottom, it is doubtful if there is any advantage in edge piling. Further, the necessity for greater precision in piling to secure proper vertical circulation in the pile makes edge piling certainly less desirable than flat piling.

NUMBER OF CROSSERS TO THE COURSE

The most effective spacing of crossers between courses of stock, depends upon several considerations. Crossers should be frequent enough to avoid sag; otherwise bowed lumber and other types of deformation will result, as well as interference with horizontal air circulation. On the other hand, as the tiers of crossers are increased in number, air movement in the lumber pile meets more resistance.

In actual yard tests to compare the relative efficiency of 3, 4, and 5 crosser piles of 16-foot pine stock, little difference was found in the amount of degrade and but slight variation in drying rate and final moisture content. Less blue stain developed in the pile having three tiers of crossers and depreciation from cupping was smallest in the five-crosser pile. Within limits the crossers do not materially affect horizontal circulation since this is primarily a movement from one side of the pile to the other rather than from end to end; but, on the other hand, in seasoning pine stock the greater the number of crossers used the greater is the liability of crosser stain or blue stain development on that part of the lumber in contact with the crosser. These defects very generally result in the degrade of select and shop grades and to a smaller extent of the better common grades, but in any case they injure the appearance of the stock.

The use of three crossers on stock 12 to 16 feet in length and of four or five crossers on longer stock is the most common practice, although a great deal of lumber is piled on two crossers with 4 feet or more overhang at the rear of the pile and very often an excessive number of crossers are employed. Everything considered, maximum efficiency can ordinarily be expected from the use of two tiers of crossers on 8-foot and shorter stock, of three tiers on 10 to 16 foot stock, and of four tiers on 18-foot and longer stock. With a span of 8 feet or less, the lumber will not sag, and on the other hand with each additional tier of crossers in the pile circulation is further obstructed and, in piles of pine, the liability to crosser stain is increased.

In the discussion of pile foundations, it was stated that each tier of crossers should bear directly upon a stringer, and for that reason the crosser practice should determine this feature of foundation construction. Unfortunately in too many instances "the tail wags the dog," so to speak, and crosser practice is shaped to fit the foundations. While a tier of crossers, unsupported by a stringer, keeps the boards

separated and facilitates air movement, the weight causes sag in the pile at this point and consequently a greater proportion of bowed stock.

STOCK CROSSERS AND SPECIAL CROSSERS

Two general types of crossers are employed in air seasoning—stock crossers and special crossers. Stock crossers come into use when green stock is crossed with itself. Special crossers, as the name implies, are strips or thicker pieces used repeatedly upon any grade or size of green lumber. The size of stock crossers is, of course, automatically fixed by the dimensions of the stock piled. The special type, however, is usually 4 inches in width, although occasionally 6 inches, and 1 or 2 inches thick. The use of stock for crossers permits rapid piling, increases the capacity of the piles, and eliminates the necessity of carrying a large amount of stock in the form of crossers. This practice, however, results in serious depreciation losses which are avoided in the use of special crossers.

The stock crosser is subject to heavy degrade from season check and is also largely responsible for this defect in the piled lumber. Checks develop in those sections of the crosser which come between the tiers of stock, or, stated in another way, in the parts which lie within the vertical flues. At these points both faces are exposed to the air, and drying proceeds much more rapidly than in the adjacent sections which are covered, top and bottom, by the green stock. The resultant uneven shrinkage causes checking in the portions which dry quickly. (Pl. 6, B–1 and 4.) A similar difference in drying rate between the crossed and uncrossed portions of the lumber causes like defect. In pine lumber conditions are highly favorable for blue-stain development in these extremely slow-drying intersections of the stock and crosser. The so-called "crosser-stain" blemish is therefore a common result of self-crossing pine lumber. (Pl. 6, B–2 and 3.)

The wide green stock crosser at the front and rear of the pile also causes excessive end checking. This results from the very marked difference in drying rate directly at the ends of the stock and in the adjacent sections which are between the crossers.

These very objectionable results of air seasoning are greatly minimized through the use of the special crosser. Special crossers being narrower and usually air-dry, or partly so, have less tendency to check. Furthermore, stock of relatively low value can be utilized for this purpose. Air-dry, narrow crossers, if properly projected beyond the ends of the stock, vary largely eliminate end checking. Not only are the conditions less favorable for stain development but the area affected is more restricted.

The relative merits of these two methods of crossing Western softwood lumber have been thoroughly investigated by means of controlled yard tests in different regions and with several species. Common pine in the Inland Empire seasoned in self-crossed piles showed depreciation which averaged 14 per cent greater than that in comparable special crosser piles—4 per cent greater degrade in the piled stock and 10 per cent in the crossers. The actual loss per 1,000 feet of stock piled in drying No. 2 common pine was over $2 more in the stock-crosser piles and the drying rate was slower, the lumber requiring one to four weeks' additional time to reach an average air-dry

condition. The stock crossers showed a final moisture content about 5 per cent higher than the stock itself.

Startling as these actual degrade losses (almost entirely from checking) in self-crossed common pine may appear, they do not tell the whole story. The stock piled on itself showed 68 per cent of the ends checked as against 16 per cent for that piled on special crossers. In self-crossed piles an average of 85 per cent of the pieces showed end checks 4 to 8 inches long, and over 50 per cent were checked at both ends. In addition, 22 per cent of the self-crossed stock was stained, as compared with 10 per cent by the other method. Although such seasoning defects do not ordinarily cause degrade in common pine, they do mean a "harder" or lower average grade. This is certainly a consideration when the lumber is sold in competition with similar stock seasoned on special crossers. A bright product with little end check is surely a trade advantage.

In Douglas fir common, it was found that degrade in the stock crossers because of season check is likely to range from 25 per cent in 1 by 8 inch stock to 75 per cent in 1 by 12 inch. In 8/4, or 2-inch No. 1 common, such degrade was almost negligible, but in 2-inch select common it averaged from 10 per cent in 2 by 8 inch stock to 25 per cent in 2 by 12 inch. These investigations also showed that season-check degrade of the regular stock in self-crossed piles is largely due to the use of stock crossers. This varies from 2 per cent in 1 by 8 inch No. 1 and select common to 20 per cent in 1 by 12 inch. With 2-inch No. 1 common, such degrade is negligible, but it ranges from 2 per cent in 2 by 8 inch select common to 15 per cent in 2 by 12 inch.

In practice the choice between special and stock crossers varies greatly with the region and species. In the Inland Empire all No. 3 shop-and-better pine is air seasoned on special crossers, and probably 50 per cent of the yards are piling some common in this manner. Other species are very generally self-crossed. In the California pine territory the practice with No. 3 shop-and-better is similar, and the use of special crossers with the common and box grades of pine is increasing. In the Douglas fir region, owing apparently to the fact that selects are not air seasoned and that the species handled do not stain, self-crossing is the common practice. Methods vary widely between redwood plants, but although stain is not a factor special crossers are often used.

Increased use of the special crosser is a definite need in all these regions. There is no question that its use on select and shop grades is entirely justified, and on certain grades of common it will avoid depreciation losses amounting to far more than the additional operating cost. The added expense, including the extra handling and piling cost as well as the depreciation of the special crosser, is very generally placed at 25 cents per thousand feet of stock piled. But even if this figure is doubled, an appreciable net saving is generally possible in addition to the production of brighter lumber in the higher grades.

Although the extent to which special crossers can be used is largely an individual-plant problem and one that justifies thorough study, certain general standards can be cited. Special crossers should ordinarily be used with pine for 8-inch and wider No. 3 common-

and-better, and with Douglas fir and western larch for 1 by 8 inches and wider No. 1 common-and-better, and 2 by 8 inches and wider select common-and-better; with at least the standard and better grades of redwood 8 inches and wider; and with at least the select grades of other species.

It is not uncommon to find special crossers used only at the rear of the pile or at the rear and center. The idea back of such methods is that the rear and center crossers are subject to greater depreciation than the front crosser. This theory does not, however, appear tenable upon review of the underlying causes of crosser depreciation, nor is it substantiated by the results of actual yard comparisons. What little variation in degrade occurs in the different tiers of crossers runs slightly higher in the front crossers and lower in the rear and center crossers.

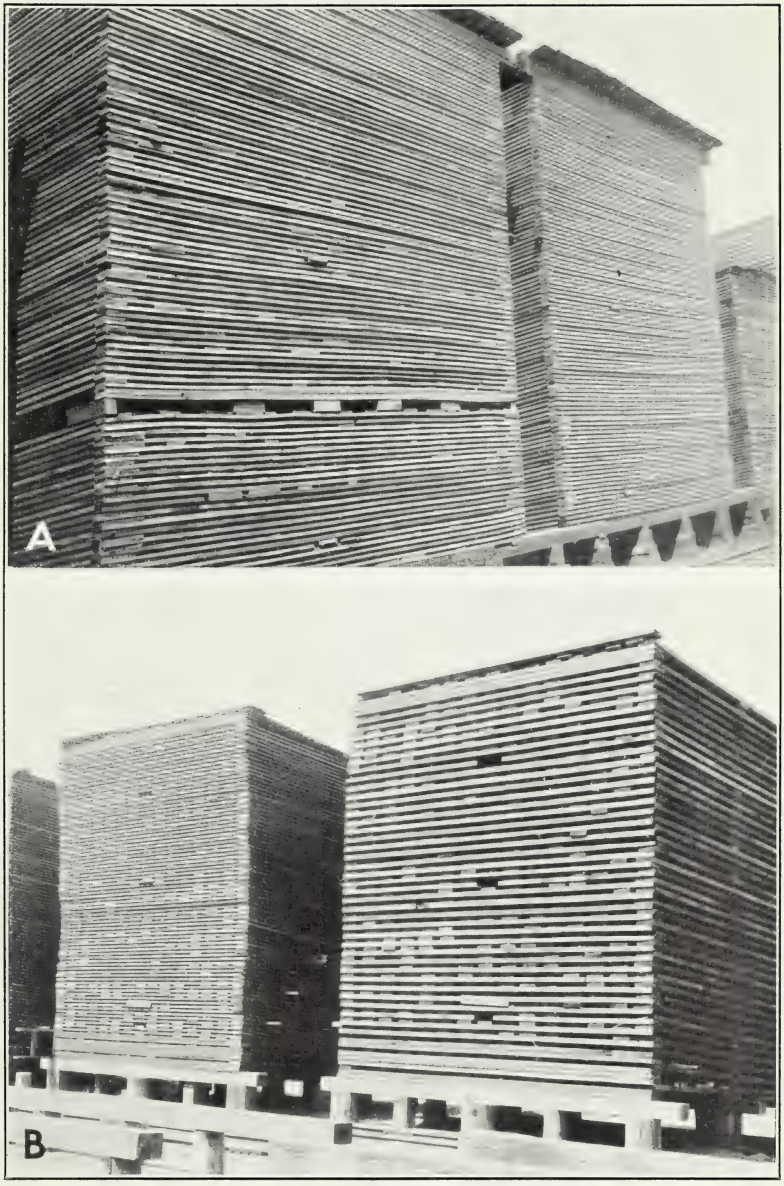
DIMENSIONS OF THE CROSSER

The dimensions of the crosser have a very direct bearing upon seasoning. The influence of the width has been brought out forcibly in the preceding discussion. Special crossers should not exceed 6 inches in width, and 4 inches is preferable. Width of the stock crosser is usually fixed by that of the stock piled. When random width lumber is self-crossed, the use of the 4 and 6 inch widths for the crossers should be definitely insisted upon, since much depreciation can thus be avoided.

Thickness of crossers is a very important item in seasoning practice. The necessity for adequate horizontal circulation in the lumber pile, and more particularly within the lower third to remove the moist air which drops into this section from above, has been emphasized. Obviously, this horizontal air movement is assisted by any increase in the thickness of crossers. Further, this means of increasing circulation in the pile is a very flexible one, since the crosser thickness can be increased in the lower section or wherever a more positive air movement is desirable, by the simple expedient of doubling the crossers at such points. And if an even greater opening is desired at intervals, three or more crossers can be employed in the same manner.

Crosser thickness, where seasoned crossers are used, may be the key to the solution of serious drying difficulties. Horizontal circulation in the pile may be increased by this means wherever it is most needed. The usual lag in drying between the upper and lower parts of the pile can thus be greatly reduced. Stain development, most severe in the lower sections, can be greatly retarded by doubling crossers in this part of the pile, without inviting the increased depreciation that would result from an equally rapid drying in the upper sections. All of these definite advantages have been thoroughly tested by numerous comparisons in the different regions.

In an attempt to cut down the time required for drying redwood the relative merits of various crosser thicknesses were studied. It was found that stock piled on 4/4 (1-inch) crossers required 36 per cent more time, and stock on 6/4 crossers 10 per cent more time to become air-dry than did that on 8/4 crossers. For the California pines, an increase in the crosser thickness not only increased the rate



A.—Eight-inch horizontal opening in lower part of pile
B.—A common method of single-length roof construction

THE DOUBLE-LENGTH OVERHANG TYPE OF ROOF IS ILLUSTRATED IN A

In B and C are shown good examples of the care in actual piling that is fully as important in softwood yards as is the adoption of improved methods

of drying but materially reduced degrade from stain. Seasoning of these woods on 8/4 crossers resulted in a depreciation of 8 per cent; on 6/4 crossers, in a depreciation of 13 per cent; and on 4/4 crossers, in a depreciation of 28 per cent.

The 4/4 crosser commonly used in the Inland Empire is mainly responsible for the appreciable lag in rate of drying between the bottom and the top of the pile. Naturally, blue-stain depreciation of pine stock at the bottom is heavy. The effect of 8/4 crossers in the lower third of the pile was compared at several plants and was found to average consistently less drying time than was necessary in piles with 4/4 crossers throughout. The stock on the 8/4 crossers reached an air-dry condition on an average three and one-half weeks earlier than that in the lower third of the other piles. Blue-stain development was less than one-third of that in 4/4-crossed stock. The final average moisture content of the stock on the 8/4 crossers was also lower, and the customary lag in drying time between the top and bottom sections of the piles was much smaller.

With pine, the use of two instead of one of the regular 2-inch crossers at evenly spaced intervals in the bottom half of the pile reduced the average degrade from 24.6 per cent to 12.9 per cent. Similar comparisons with redwood showed a reduction in degrade from 18 per cent to 5 per cent, and during a six-month drying period the stock piled with double crossers lost 28 per cent more moisture.

Such methods are not only effective in building up the horizontal circulation but are easily applied in the yard. The use of two sizes of crossers in the individual yard is objectionable, of course, but this is unnecessary. Two or more crossers of the customary thickness placed one on top of the other answer the purpose nicely. If, instead, 4 by 6 by 12 inch blocks are placed under single crossers at intervals, this not only permits increased sidewise circulation but also gives entrance to the wind currents in the front and rear alleys, which are normally shut out by the crossers. (Pl. 7, A.)

The actual practice in the West varies greatly. In the Douglas fir region, where practically all stock is self-crossed for air seasoning, the thickness of the crosser conforms to that of the lumber being piled. The 4/4 crosser is the general standard in the Inland Empire, although some pine shop and selects, especially 5/4 and thicker stock, are piled on 8/4 crossers, and the practice of opening up the lower part of the pile with thicker crossers is increasing. In the California pine territory the 8/4 sticker is the standard. Strangely, in the redwood region, where slow drying is the big problem, the 4/4 sticker is commonly employed.

In any attempt to improve seasoning conditions the question of crosser thickness must be analyzed carefully. It should be clearly recognized that positive horizontal circulation, particularly in the lower part of the pile is a very necessary adjunct to the natural downward air movement in the lumber pile. Horizontal circulation is imperative if the lag in drying between the upper and lower halves, and hence the average drying time, is to be satisfactorily reduced and depreciation, chiefly from stain, is to be avoided. Variation of the crosser thickness is the most flexible means of influencing horizontal circulation.

SPECIES EMPLOYED AS SPECIAL CROSSERS

Various species are used as special crossers. In the Inland Empire the larch-fir strip is generally employed, although cedar and white fir are used to some extent. The white-fir crosser is most common in the California pine region, Douglas fir being second in importance for this purpose. Douglas fir is also the chief species used in the redwood territory. In the Douglas fir region the practice of self-crossing stock fixes the kind of crosser used.

At any plant, availability of suitable species and grades plays an important part in the kind of crossers used. But within such limitations, three considerations should serve as guides. Where pine is to be seasoned, susceptibility to stain is of first importance; obviously, species and grades which do not favor stain development should be selected. Mechanical properties which will enable the crosser to stand up under the usual wear and tear incident to such use are also necessary. And the value of the material utilized of course bears directly upon the investment which must be carried, as well as upon the amount of the actual losses due to breakage and other forms of depreciation.

CONDITION OF THE CROSSER

It is customary at a majority of plants to use special crossers repeatedly until they are worn out. Some of the more progressive companies, however, attempt systematically to dispose of this crosser stock after it has been used three or four times. This is a very desirable practice, especially in yards where pine is handled. Not only does this permit the sale of such stock before it is seriously depreciated (probably a drop of one grade on the average), but it also avoids the possibility that with prolonged use the crossers may become a source of blue-stain infection. Although the crossers may be made of species not susceptible to blue-stain development, their use on stain-infected pine stock and careless handling and storing about the yard soon results in their collecting blue-stain spores which readily transmit new stain infections to the piles of freshly cut pine.

Actual comparisons to determine the effect of the age of the crosser upon crosser-stain development showed that stock piled upon old crossers was stained two-and-a-half times as much as that piled on new seasoned crossers. This same test brought out the fact that the use of green crossers resulted in four times as much crosser stain as did the use of new dry crossers. Investigation also indicates that a rough crosser causes less stain than a surfaced crosser. Unquestionably, rough seasoned crossers which are disposed of after a short period of use will give the most satisfactory seasoning results.

PLACEMENT OF THE CROSSER

After the general plans for crossing stock has been settled, standard methods for the actual placement of the crossers should be adopted. Periodic yard checks are then necessary to see that the prescribed standards are being carried out in practice. The placement of crossers, as practiced throughout the West, embraces both good and bad practice. One of the most general violations of good

practice is that of improper bearing of the crossers. Bowed stock and other forms of depreciation result from crossers not bearing directly on those beneath. The vertical alignment of each tier of crossers should approximate the pitch of the pile. The front crosser, and the rear crosser in box piles, should be consistently placed so that they project beyond the ends of the stock. When stock 6 inches and wider is self-crossed, at least 2 inches of the crosser width should overhang to avoid end checking, and where 4-inch special crossers are employed this overhang should be at least 1 inch. The difficulties of this method are greatly exaggerated and the merits fully justify insistence upon its use. Observation alone should convince any one of the effectiveness of this practice, even if actual pile comparisons did not fully substantiate it. In pine stock piled with the crossers flush with the ends, eight times as much check developed as in stock protected by overhung crossers. A similar test with inch Douglas fir stock showed end checking of 20 and 3 per cent, respectively, when the two methods were employed.

Some yards using stock crossers, particularly stock 8 inches and wider, stagger the center and rear crossers about half their width. (Pl. 5, D.) By this method, the portion of the board ordinarily covered on both sides by the crosser is exposed to the air on one side. This results is a slightly lower final moisture content in these sections, and it is said that less checking of stock and crossers occurs. On the other hand, such practice does not lessen crosser stain and, especially with 4/4 stock, invites depreciation in the form of bowed, warped, and twisted lumber.

SPACING BETWEEN BOARDS

A fundamental principle of air-seasoning and one which apparently fails to receive proper recognition in yard practice, is that there must be vertical air circulation in the lumber pile. This internal downward movement resulting from the natural tendency of the moist air, cooled by evaporation, to drop toward the bottom of the pile, must be positive throughout the pile in order to make the drying process most effective. Best results are therefore obtained when lumber is piled in even widths, permitting unbroken vertical flues extending from the top to the bottom of the pile between each two tiers of boards. In random-width stock such construction is ordinarily impracticable, and, accordingly, a relatively wider spacing between boards in the course is necessary to offset as far as possible this disadvantage.

The interval between boards can to some extent control the rate of drying. Extremely rapid drying and consequent depreciation from checking can be moderated by a reduction of this spacing. On the other hand, the drying rate can be increased, the lag in drying between lower and upper sections of the pile can be decreased, and blue-stain losses reduced by a greater spacing. One obstacle, however, to control of drying rate by spacing is that wide spacing reacts proportionately in all parts of the pile and thus may improve the drying process in one portion at the expense of creating a more serious condition in another. Hence, spacing must be supplemented by other methods in order to obtain the most uniform drying.

To determine the relative efficiency of different spacings with even-width stock, tests were conducted on both select and common grades of pine during different seasons of the year and at several plants in the inland empire. The results obtained (Table 5) were very consistent and point conclusively to a definite relationship between drying conditions and width of spacing. They show that the rate of drying is materially affected. Stain losses can be greatly reduced by increasing the spacing, and increases of the interval up to 4 inches at least do not appreciably increase the occurrence of

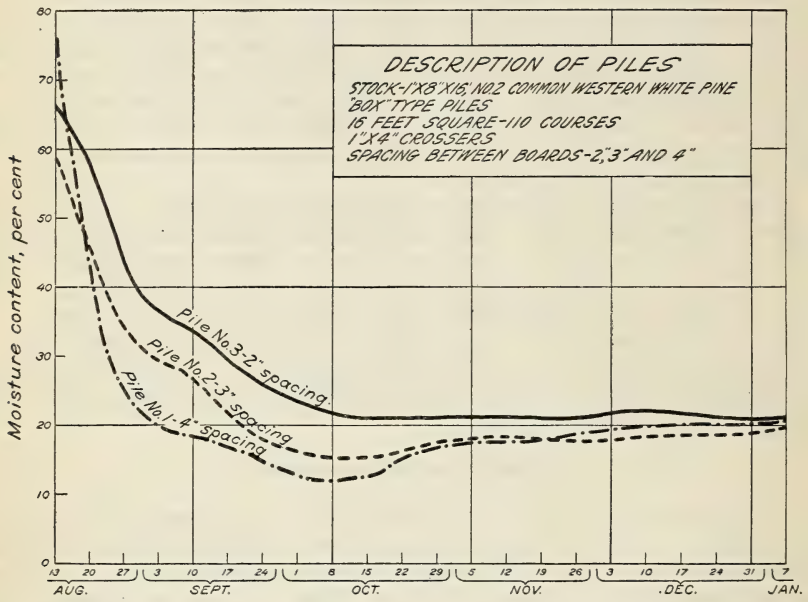


FIG. 5.—Comparative "pile average" drying rates for stock piled with different spacing between boards

shrinkage defects. Figures 5 and 6 allow a visualization of the influence which the spacing exerts upon drying rates. Figure 6 also indicates that by this means the lag in drying in the lower part of the pile can be to some extent reduced.

TABLE 5.—*Effect of different spacing between boards in the lumber pile*

Spacing	Pieces stained	Degrade				Loss per M feet			Final moisture content	Time required for air-drying
		Stain	Check	Knots	Total	Stain	Check	Total		
Inches	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*				*Per cent*	*Weeks*
4	21.5	3.7	0.4	1.8	5.9	$0.57	$0.07	[1]$1.25	15.5	15
3	29.4	6.4	.3	2.5	9.2	1.33	.16	[1] 2.33	15.0	18
2	38.4	10.5	.7	2.4	13.6	1.75	.14	[1] 2.87	15.7	25

[1] Total figures are not the sum of those in the 2 preceding columns.

The practice of spacing even-width western softwood lumber for air seasoning is naturally far from uniform. The numerous species, grades, and sizes involved, the great variation in general piling prac-

tice, and differences in natural conditions present a variety of problems. However, the wide differences in practice indicated below are too largely the result of failure to appreciate fully the basic relationship between spacing and the drying process and so to give recognition to it in pile construction:

Region	Average spacing	Range
	Inches	*Inches*
California pine	4	2–8
Inland Empire	3	1–6
Redwood	[1] 2	½–2
Douglas fir	[1] 2½	½–4

[1] Approximate.

Proper spacings must be worked out at each plant, due weight being given to the facts presented here. Coordination with other requirements in pile constructions is also essential. As a general guide, it may be stated that wide stock requires a greater spacing

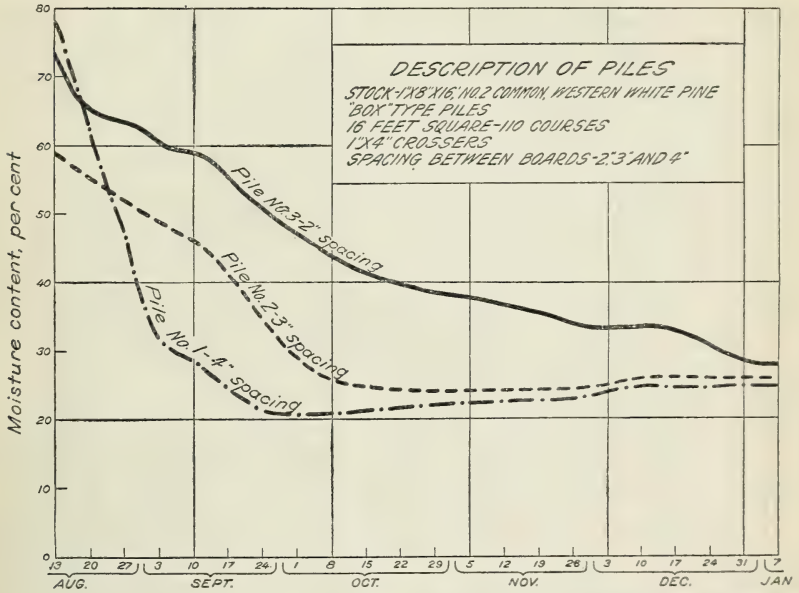


FIG. 6.—Comparative drying rates in lower third of pile for stock piled with different spacing between boards

than narrower stock, 5/4 and thicker stock requires more than 4/4 stock, and pine, because of its susceptibility to stain, more than other species. A dual system may be necessary to meet the drying extremes of different seasons. Standard practice may call for a narrower spacing during the active drying season than will meet the needs during the rest of the year.

In piling random-width stock, the usual practice of allowing a fixed interval between boards irrespective of their width permits no unbroken flues from the top to the bottom of the pile. As stated be-

fore, a relatively wider spacing is necessary than for even-width stock in order to offset this lack of well-defined channels for vertical circulation. The effect of increased width is well shown by actual yard comparisons. Random-width 6/4 No. 1 shop-and-better sugar pine piled with a 3-inch spacing resulted in a total degrade of 11.8 per cent; with a 5-inch spacing, in a degrade of 5.3 per cent; and with a 7-inch spacing, in a degrade of 4.8 per cent. The reduction in stain development accounts for practically the total difference between the first and second tests. Although stain was practically eliminated by the 7-inch spacing, increased defects resulting from very rapid drying largely discounted that advantage. This indicates that methods of hastening seasoning must not be carried too far.

Although in each region the spacing allowed in piling random-width stock averages slightly larger than that employed for even widths, a still wider interval is very generally needed. At numerous plants a real improvement in seasoning conditions can be obtained by this means.

CHIMNEYS OR VENTS

Very closely related to proper spacing is the procedure of building chimneys or vents into the lumber pile as a means of improving vertical circulation. Chimneys are unobstructed vertical openings quite distinct from the flues obtained by the uniform spacing of even-width stock. They are normally wider than flues and are located only at the center of the pile or at definite intervals across the width Their most effective use is with random-width stock.

Little uniformity in the practice of using chimneys is evident, and this results in large measure from a lack of accurate knowledge of the real influence of this feature of pile construction upon actual drying conditions within the lumber pile. At some redwood plants both even and random width stock are piled with two chimneys 10 to 16 inches wide, and at others no chimneys are employed. In the California pine territory the chimney is little used with even widths, but the straight center vent 8 to 20 inches wide is very generally utilized with random stock. Inland Empire plants rather commonly pile even-width pine with an 8-inch center chimney and employ a large assortment of vent combinations in the seasoning of mixed widths. A 6 to 12 inch center chimney is most common. Two 8 or 10 inch chimneys are not unusual, and some plants make use of from three to eight narrow vents distributed across the pile. Chimneys find little use in the Douglas fir region and where employed are generally of the single center type.

Since the only purpose of chimneys is to aid vertical circulation throughout the lumber pile, it is more logical in seasoning even-width stock to increase the spacing between the boards in a course and thus the width of the vertical flues, than to use a relatively narrower spacing and place a center chimney in the pile. This conclusion has been confirmed by numerous actual yard comparisons of the results obtained from both methods of piling. At several plants in the Inland Empire even-width pine stock piled with a 3-inch spacing was air-dried in less time and developed slightly less stain than did the same stock piled closer and given a 12-inch center chimney. In the Douglas fir region, piles with 2-inch spacing and a

10-inch vent at the center failed to show any increase in either the rate or uniformity of drying over piles with a 3-inch spacing and no vent.

An adaptation of the chimney method may, however, be used to advantage with even-width stock in yards where the evils resulting from slow drying in the lower part of the piles are a primary problem. What are in effect short chimneys are formed by simply eliminating every other board in the course for the first 4 or 5 feet of the pile. The merits of such a method are the increase of vertical circulation in that part of the pile where it is most needed at a sacrifice of space in that section alone. The obvious disadvantage, that of insufficient bearing surface for the crossers, is not serious except with wide stock.

The use of chimneys in piles of random-width stock is of course entirely justified. It is, indeed, the only practicable means of creating a direct vertical circulation in piles of this type. The single straight center chimney is undoubtedly of value, but the rate and degree of drying attained are far from being as favorable as those obtained in properly constructed even-width piles; and stain losses are usually very heavy. Two chimneys are likely to give better average conditions, although the center section of stock between them is probably subject to more severe stain depreciation. The center A-shaped or "flared" chimney, 8 inches in width at the top and 22 inches wide at the bottom, is superior to either single or double straight chimneys. It not only makes a maximum provision for vertical circulation where that is most needed but in so doing eliminates stock from that part of the pile which is subjected to the very worst drying conditions. This method is also economical of space in the upper sections.

If three to eight chimneys are employed, evenly distributed from one side of the pile to the other, an approach is made to the desirable conditions obtained in piling even-width stock. Positive vertical circulation throughout the pile is more nearly attained. Within each of the four to nine vertical sections of stock thus set apart the boards in a course should be placed as nearly tight as the widths will permit when the outer boards of each section are kept flush with the sides of the chimneys. This general system has advantages over the other chimney methods discussed. The pile capacity is greater because of the relatively narrow chimneys, usually 6 or 7 inches, and the close piling between them. The rate of drying is more rapid, and less stain develops as a consequence. Degrade from checking is also smaller because, although the chimneys allow good vertical circulation, the principal effect of this is to build up the horizontal air currents that permit uniform drying across the face of the stock. On the contrary, with fixed spacing between the boards in a course, short flues occur blocked above and below by wider boards. Air currents following these flues strike the projecting board and effect an unequal drying that often causes checking.

Controlled yard tests of these several methods show clearly that the use of chimneys in random-width stock has a very definite effect upon drying and indicate the relative merits of the different methods. Comparisons were made of the pile without chimneys, the pile with two 12-inch chimneys 4½ feet apart, and the pile with a center flared

chimney 8 inches wide at the top and 22 inches wide at the bottom. Random-width 6/4 shop and select western yellow pine stock was used in all piles. Pile construction without chimneys resulted in a total degrade of 24.6 per cent, as compared with 16.6 per cent from the two-chimney method and 9.2 per cent from the use of the flared chimney. Most of the depreciation in all piles resulted from stain, the rate of drying being fastest in the flared-chimney pile and slowest in the no-chimney pile.

The results obtainable from the common 12-inch center chimney were compared with those from piling with five 7-inch chimneys evenly distributed across the pile and the boards on a course placed approximately solid within the six vertical sections of stock. Random-width 4/4 select western white pine stock was used. The five-chimney method resulted in 10 per cent less stain development, a 3 per cent smaller degrade from stain, and only half the loss from season check. The actual degrade loss was $2.75 per thousand less by the five-chimney method, stock reached the air-dry condition two weeks earlier, and the final moisture content was slightly lower.

As is true with all phases of pile construction, the use of chimneys or vents must be adapted to the situation at each plant. It is possible, however, to set up some very definite principles as a guide. In piles of even-width stock the use of chimneys is not as effective as is an equivalent increase in the width of the unbroken vertical flues between the uniformly spaced boards. In piling random-width stock, a single straight center chimney at least 12 inches in width is an improvement over no chimney; but less piling space is sacrificed and much more efficient seasoning is obtained by the use of three or more smaller chimneys evenly distributed across the width of the pile. Where three or more uniform chimneys are impracticable, as is often the case with very wide shop and select grades of California pine, a single flared chimney at least 22 inches wide at the bottom will prove more effective than a single straight chimney.

It should be realized that the use of chimneys is only one of several means to obtain more efficient drying within the lumber pile. If sluggish drying is to be overcome, any system of chimneys must be supplemented by one or more of the other means.

ROOFS

A good pile covering improves seasoning by protecting the stock from rain and snow and from full exposure to the direct rays of the sun. Some operators believe that, at least during seasons of light precipitation, lumber seasons more rapidly in unroofed piles. Whatever slight advantage there may be in this practice is, however, more than offset by its disadvantages. In seasons of sparse rainfall, when the most rapid drying can be expected in unroofed piles, the direct exposure to the sun and the consequent excessive rate of drying cause heavy depreciation from cup, warp, twist, and check in the upper portion of the pile. At no time is alternate drying and wetting of stock an aid to seasoning; generally it only invites depreciation.

Stock is commonly roofed with itself or with special roof boards. Special roofing has definite advantages. It is possible to utilize material of the size best adapted to the purpose and of the species

and grades of lowest value. Use of cheaper lumber is very important because of the high depreciation of roof boards. In actual checks of such depreciation, when No. 2 common-and-better pine stock was self-roofed, 70 per cent dropped at least one grade. If No. 3 or No. 4 common were used to roof the better stock, a net saving of $2 could be made on each pile, over and above depreciation and extra handling of the special roof material. Although practice must, of course, be in accord with the local situation, since the price differential between grades varies with the species and climatic conditions also have a direct bearing upon the depreciation of roof boards, yet, as a general rule, the select and shop grades of all species, No. 1 and No. 2 common grades of pine, and if possible the upper common grades of other species, should be covered with special roof boards. This now constitutes the accepted practice in the majority of western yards.

The essentials of proper roof construction are, (1) sufficient pitch to assure run-off, (2) suitable material and lapping to avoid leakage, (3) overhang at the front and rear of the pile, and (4) some clearance between the stock and the roof. Two general types of roof are commonly employed—that which provides a front and rear overhang and that which does not. The "overhang" type is constructed in two ways; with boards 2 to 4 feet longer than the piled stock or with double lengths of boards. The former method requires the use of special rood boards while the latter may be built with stock. The second type of roof, that which does not project beyond the ends of the pile, is constructed of boards the same length as the stock and is most commonly used when stock is roofed with itself.

Plate 7, B shows the common method of single-length stock roof construction. It consists of two layers of boards, the top course lapping the lower course of boards which are spaced several inches apart upon supporting stringers. These stringers, which bear upon the crossers and usually consist of crossers or stock laid one upon the others, form supports of different heights, the center lower than the front and the rear lower than the center. The double-length roof, as illustrated by Plate 8, A, is simply an adaptation of the former to give overhang at the front and rear of the pile.

Adequate overhang of the roof at the front and particularly at the rear of the pile is very desirable. This gives some protection from rain and snow beating in at the ends of the pile, and by the shade afforded tends to avoid end checking in the stock on the upper courses. It also allows the drip from the roof to fall clear of the pile. The need for sufficient pitch to secure good run-off is obvious. The clearance between the roof and the stock is ordinarily sufficient for air circulation if adequate pitch is provided. Little difference in effect upon seasoning was indicated for roofs 1 inch, 6 inches, or 10 inches high, although the rate of drying in the upper third of the pile may be slightly increased with the higher roof. The use of several crossers to hold the roof boards in place is usually satisfactory, but in windy situations or period of the year it is generally advisable to fasten roofs to the piles with wire or roof irons.

Although the tendency toward improvement in the style and workmanship of roof construction is very noticeable in the West, much can yet be done along this line. All stock should be roofed during air seasoning. Ordinarily, the use of stock roofs is justified only on the lower grades of common lumber. Adequate overhang, at least

12 inches at the front and 2½ feet at the rear, is essential. A pitch of 1 inch to each foot of length is required to assure good run-off, and the height of the roof over the rear tier of crossers should best be about 4 inches. Drip boards, sometimes used with roofs that have no overhang to throw drip away from the rear of the pile, are praised by some and condemned by others. However, this method is far less effective than the overhang type of roof.

SUMMARY OF METHODS FOR IMPROVING DRYING PRACTICE

It has been stated, and the preceding discussion of the entire air-seasoning process must certainly have led to the very definite conclusion, that the air-seasoning problem can not be solved by "cut-and-dried" rules. Neither the present discussion, based though it is on comprehensive and detailed studies, nor any other intensive investigation of air seasoning, can alone determine efficient practice for every yard. Fundamental information on drying can be given and its application indicated in a general way. This material may be used by the individual as a guide, but only as a guide, in working out his own problem. He must give much time and effort to checking for his own yard the effect of different methods and combinations of methods upon stock depreciation, rate of drying, final moisture content, operating costs, and yard-space requirements. And such time and effort can without question be made productive of handsome financial return through greater efficiency in air seasoning.

Will these very definite though intangible returns be appreciated at their full value and prove an incentive to improved yard operation? The small plant, whose yard crew may consist of two or three men working under the direction of the man in charge of the entire manufacturing operation and the great plant having an enormous daily production, with its yard superintendent and assistant, green and dry lumber foremen, stock clerks, piling crews, dry-lumber handlers, transportation crews, trackmen, foundation-repair men, crosser men, and clean-up men, both have one thing in common. The men who are qualified and who naturally should have the incentive to check and study seasoning methods in relation to actual results are so pressed with supervisory and other duties that little thorough work of this nature is possible. To this situation the majority of the difficulties and failures in air seasoning can very largely be charged. Real efficiency in air-seasoning practice must have accurate detail knowledge for its basis.

Indirectly, the major objectives of air seasoning are obtained by control of the drying rate. The aim of any method is therefore primarily to create conditions conducive to either faster or slower drying. The more general principles of bringing such conditions about should accordingly be summarized.

If more rapid drying generally is desired, the means most applicable are the following:

Improved yard drainage.
Eradication of vegetation.
Wider spacing between sides of the piles.
Higher foundations.
Narrower piles.
Thicker crossers.
Wider spacing between boards.
Chimneys in random-width stock.

To obtain faster drying in the lower part of the pile and thus decrease the differential in rate of seasoning between the bottom and top sections and to reduce as well stain development in the lower portion without increasing the rate in the upper part, the following methods are of value:

Thicker crossers in lower third of pile.
Horizontal openings at intervals.
Short chimneys at bottom of piles of even-width stock.
Flared chimneys in random-width stock.

The elimination of stock depreciation resulting from excessively rapid drying, which usually occurs in the upper half of the pile, can be attained with little slackening of drying in the lower half by such practices as—

Narrower spacing between piles.
Thinner crossers in upper half of pile.
Narrower spacing between boards.

In the development of air-seasoning practice the manner in which piling is done is a consideration of major importance. No matter how efficient are the methods adopted, the results are in no small measure dependent upon the actual construction of the individual pile. Flues and chimneys must be carried up without being obstructed by carelessly misplaced boards. (Pl. 8, B.) In random-width stock if less than three chimneys are used consistent spacing between boards is essential. Each crosser should bear directly on the one beneath. (Pl. 8, C.) The front and rear crossers should always project beyond the stock to afford protection to the ends. (Pl. 8, B.) When random-width lumber is crossed with itself, reasonable effort should be made to select the narrowest widths for crossers. Finally, careless handling should not be tolerated, since this can mean a very appreciable loss.

Any means of supervision or system of payment for piling that will assure careful pile construction should be followed. Observation in numerous yards indicates that piling by men paid day wages usually comes nearer to consistent attainment than does the contract method. An increase in the piling cost of as much as 25 cents per thousand feet looks small in comparison with some of the proved savings from reduced depreciation. One principle should be firmly fixed: Improvement of the air-seasoning practice is of first importance, and prejudices and preferences of the lumber piler as to the manner of doing his work are secondary.

REGIONAL AIR-SEASONING PROBLEMS AND THEIR SOLUTION

INLAND EMPIRE PINE REGION

GENERAL CONDITIONS

The pine-producing region known as the Inland Empire is usually considered as embracing Montana, Idaho, and those sections of Washington and Oregon east of the Cascade Range. Naturally, within a territory of this size considerable variation in weather conditions is found. The region, as a whole, is, however, distinguished by certain common climatic characteristics which exert rather definite influences

upon the air seasoning of lumber. Figure 7, although based on weather data obtained only in western Montana, northern Idaho, and eastern Washington, illustrates characteristic features of the Inland Empire. Two well-defined periods are indicated—an active drying season which ordinarily extends from April 15 to October 10, and a much less favorable period of drying during the remainder of the year. Particularly in the spring and fall, warm days with relatively high humidities are common. Such conditions are ideal for blue-stain development. During the summer months periods of extremely low humidity cause excessively rapid drying.

The kinds of lumber produced, of course, influence the seasoning practice. Western yellow pine, now designated pondosa pine by

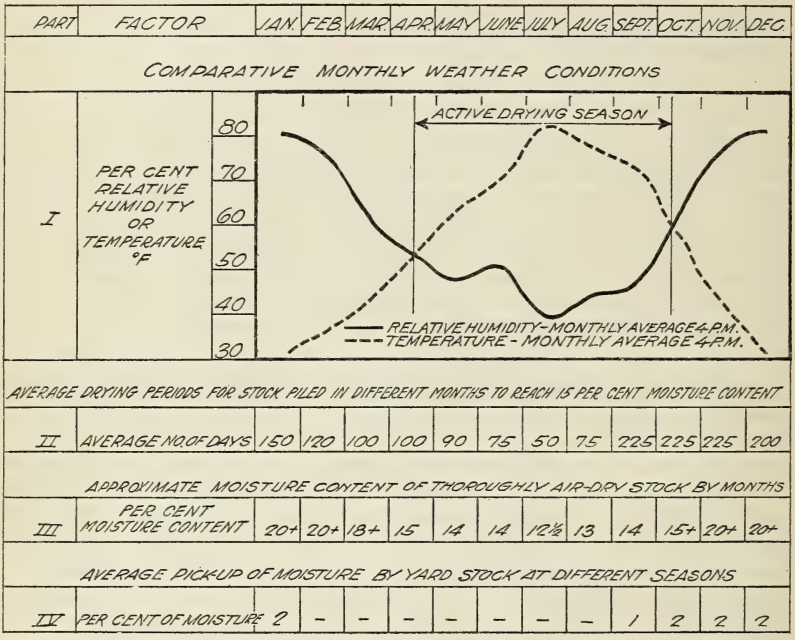


FIG. 7.—Graphic air-seasoning chart for the Inland Empire

the industry of the Inland Empire, constitutes nearly half of the annual cut. The western white pine, or Idaho white pine, is next in importance, although the combined production of larch-fir exceeds that of the white pine. White fir is also cut in appreciable volume. Western red cedar, Engelmann spruce, western hemlock, and lodgepole pine are of comparatively minor commercial importance. (Table 1.)

Certain manufacturing practices characteristic of this territory have a real bearing on the air-seasoning problem. The region is primarily a "board" producer, a very large proportion of the cut being in the form of 4/4, or 1-inch stock. Only a small quantity of pine is cut heavier than 6/4. Larch-fir goes into 2-inch and thicker products to a greater extent than any of the other regional species. Considerable 6/4 white fir is now cut. Most of

the board production is in widths of 12 inches and less, owing to the relatively small size of the region's timber; although wider stock is ordinarily found in the thick sizes of pine. The average length of the stock is about 16 feet, with the possible exception of shop and thick select lumber.

Each producing region has seasoning methods peculiar to that locality, for many of which it is difficult to find logical explanation. In the Inland Empire width of main alleys is exceptionally good, but the width of the rear alleys and the spacing between the sides of the piles are generally inadequate. Comparatively low foundations are the rule. With the exception of shop and thick select lumber, stock is usually piled for air seasoning in separate widths and to a much smaller extent in separate lengths. The square or box type of pile is most frequently used and the heights are usually 90 to 100 courses of inch lumber. The 4/4 crosser is standard for the region and the common grades are largely self-crossed. The usual spacing allowed between boards in a course is 3 inches for pine and 1 to 2 inches for other woods. An 8-inch center chimney is very often built into piles of separate-width stock, the 8 to 12 inch center chimney being commonly employed with random widths. Special roof material finds rather general use on No. 2 common-and-better pine and on the selects of other species. The overhang type of covering is now used at a majority of the plants.

RESULTS FROM PRESENT PRACTICE

Exact piece-depreciation records obtained for about a million feet of stock in the Inland Empire are summarized in Table 6. These indicate something of the losses being sustained in average current practice. Although confined to the pines, such information if properly analyzed permits some very definite conclusions as to the really vital problems of air seasoning in the Inland Empire. Certainly these results are ample justification for active interest and attempted improvement in the air-seasoning practice.

From the standpoint of stock depreciation blue-stain prevention is of major importance. It is the cause of serious losses in western yellow pine and is of material consequence, though less severe in white pine. Depreciation of this kind is naturally more severe in the shop and select grades than in the common. With present practice the losses are much greater in the lower third of the pile, probably averaging two and a half times those in the upper third. Stock piled in the spring and fall is most subject to blue stain; winter-piled lumber is least affected. Stain is not a factor with the regional woods other than pine.

Season-check losses and end checking are also matters of concern. The more frequent occurrence of these defects in the common grades results directly from the rather common practice of self-crossing such grades, whereas shop and selects are always seasoned on special crossers 4 inches in width. It is clearly shown that the white pine is more susceptible to this type of depreciation than the western yellow pine. Larch-fir and white fir also suffer losses of this kind. Checking occurs to a much greater extent in the upper half of the pile and, as would be expected, is of greatest severity during the summer period.

Depreciation from knot defects is uniformly a factor with all grades and species because of the fact that certain knots will loosen in seasoning no matter what the system or methods employed. Degrade of this kind is usually somewhat smaller during the inactive seasoning period, owing to the relatively higher moisture content of air-dry stock at that time. Warp-bow-twist, although the cause of material losses at individual plants, is of relatively minor consequence for the region as a whole.

A comprehension of usual drying rates and average final moisture contents, which apply to air-seasoned stock during the different months of the year in the Inland Empire, can be obtained from Figure 7. Admittedly these will differ somewhat in different yards and in the same yard during years in which the seasons vary considerably from the normal. Nevertheless, these are indicative of the average results obtainable in air seasoning 4/4 pine stock in this region and point to some very definite problems.

With present yard practice, stock will reach a moisture content of 15 per cent in 90 days or less only if piled during May, June, July, and August. If piled during the period from September to January, more than six months is required to reach the same level. It is also shown that during only half the year, April to September, it is possible to obtain a moisture content as low as 15 per cent. Furthermore, stock which may have reached a moisture content lower than 15 per cent by the middle of September will begin to pick up moisture at a comparatively rapid rate if left on crossers in the yard, and by February may contain 23 per cent or more moisture. Such conditions necessarily mean a relatively heavy carrying charge for the stock and high shipping weights and unsatisfactory moisture contents during certain periods of the year.

TABLE 6.—*Depreciation in air seasoning—Inland Empire studies*

WESTERN WHITE PINE

Class of stock	Rough-dry grade																Surfaced grade				
	Pieces stained[1]	Degrade					Ends checked[2]	Footage loss	Loss in value per M feet[3]							Total degrade	Loss per M feet			Footage loss
		Stain	Check	Knots	Warp-bow-twist	Total			Stain	Check	Knots	Warp-bow-twist	Trims	Mis-manufacture	Total		Seasoning	Mis-manufacture	Total	
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*								*P. ct.*				*P. ct.*
No. 1 and 2 common	12	0.5	3	3	------	6.5	20	0.4	$0.10	$0.70	$0.59	------	$0.12	$0.20	$1.71	14	$3.71	$0.91	$4.62	0.2
D and better selects	31	10	.5	2	------	12.5	4	1.5	3.59	.14	.63	------	1.13	------	5.49	16	10.60	3.54	14.14	5.6
Piled during—																				
Winter	3.5	------	9	2.5	------	11.5	36	.7	------	1.79	.54	------	.14	.95	3.42	13.5	------	------	------	------
Spring	35	7	.5	.5	------	8	3.5	1.5	1.99	.19	.17	------	1.21	------	3.56	19.5	------	------	------	------
Summer	18	3	3	2.5	------	8.5	6	.4	1.12	.62	.47	------	.13	------	2.34	15	------	------	------	------
Fall	19.5	4.5	1	3	------	8.5	14	.7	1.69	.17	.79	------	.54	------	3.19	12	------	------	------	------
WESTERN YELLOW PINE																				
No. 1 and 2 common	19	4	2	6.5	0.5	13	16	0.3	$0.47	$0.26	$0.83	$0.06	$0.06	$0.07	$1.75	20	$2.16	$1.70	$3.86	0.4
D and better selects	45	35	.5	3	.5	39	6	.8	8.91	.15	.92	------	.20	------	10.18	------	------	------	------	------
Piled during—																				
Spring	20.5	10	.5	2.5	.5	13.5	8	.2	1.76	.08	.34	.07	.05	------	2.30	19	------	------	------	------
Summer	6.5	------	2	11	.5	13.5	9	.3	.01	.23	1.51	.02	.11	.03	1.91	22	------	------	------	------
Fall	28	4	3	7	.5	14.5	27	.4	.45	.40	.87	.06	.05	.16	1.99	20	------	------	------	------

[1] Based on percentage of pieces degraded one or more grades.
[2] Actual footage loss during seasoning—includes trims or rips made to hold grade.
[3] All losses based on average prices 1921–1923, as reported by Western Pine Manufacturers' Association.

RECOMMENDATIONS FOR IMPROVEMENT

The major air-seasoning problems of the Inland Empire should be evident. Briefly, these are (1) the reduction of blue-stain development on pine stock, (2) the minimization of checking, (3) shorter seasoning periods, and (4) lower final moisture contents. Without attempting to prescribe any "cure-all" for these difficulties, nor to outline an "ideal" practice for the specific yard, certain general suggestions for improvement can be made, which, if followed, will aid in the solution of the big regional problems and should assist the local yardman in the determination of efficient practice at his own plant.

Any adequate measures for the reduction of blue-stain development will also tend to shorten the seasoning period and lower the final average moisture content. On the other hand, most remedies for checking are in direct opposition to such measures. But this situation is not as hopeless as it might at first appear. Methods of blue-stain prevention and of season-check reduction can fortunately be nicely harmonized because of the nature of these defects. Stain development is most severe on western yellow pine during spring and fall, in the lower part of the pile, and on the shop and select grades and the narrow sizes. On the other hand, maximum checking occurs with the white pine during the summer period, in the upper part of the pile, and on the common grades and wide sizes. It is also true that the greatest single factor contributing to long drying periods and unsatisfactory final moisture content is the lag in drying at the bottom of the pile. Reduction of this lag is possible without increasing the liability of checking in the upper section of the lumber pile.

General conditions surrounding air seasoning in the Inland Empire can be bettered to great advantage, as follows:

In many yards, improved drainage, better sanitation, and current eradication of vegetation are essential.

Wider rear alleys and an increase in the spacing between sides of the piles are necessary.

An outstanding need is that of higher foundations.

Stock should always be piled one layer to the course.

The use of special crossers 4 inches in width is essential on 8 inch and wider No. 3 common-and-better pine and No. 2 common and better grades of the other woods.

The lower third or half of the lumber pile should be of more open construction to facilitate both the vertical and horizontal circulation. The 8/4 crosser should be used generally for that purpose and in 5/4 and thicker western yellow pine throughout the pile.

In piles of separate-width stock a minimum spacing of 4 inches between boards in a course should be allowed during the inactive drying season, this being reduced during the rest of the year if checking is serious.

Random-width stock should be given a uniformly wider spacing unless the more desirable practice of three or more chimneys is feasible. Finally, the practice of taking down and close piling stock that is thoroughly air-dry at the end of the active drying season should be greatly extended in the interest of lower shipping weights and satisfactory moisture content.

CALIFORNIA PINE REGION

GENERAL CONDITIONS

The California pine region includes the Klamath Falls district of south-central Oregon as well as the pine territory of California. It extends, therefore, from southern Oregon through the entire length of the Sierra Nevada Range in California and embraces both sides of that range and of the Coast Range northward from San Francisco. However, in spite of the diversity of weather conditions which such an extent of territory involves, the region as a whole is characterized by certain common climatic features which to a considerable degree unify its air-seasoning problems. The comparative monthly weather data presented in Figure 8 are a composite of the

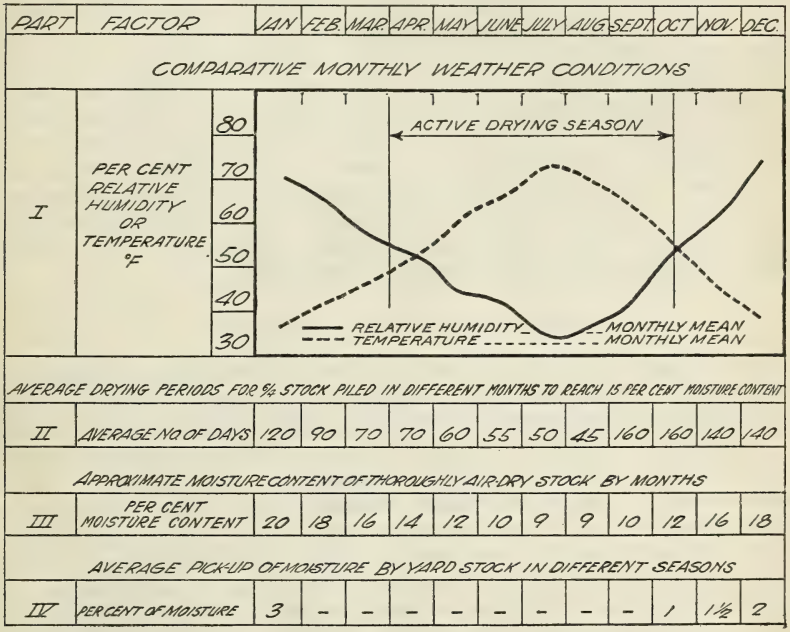


FIG. 8.—Graphic air-seasoning chart for the California pine region

relative humidities and temperatures encountered at several fairly representative points and are given simply that the reader may visualize the most striking regional features. In this area, as in the Inland Empire, distinct active and inactive drying seasons occur. However, the active period is of longer duration in the California pine region, and the extremes are less severe, particularly during the inactive season. This means relatively less difficulty with rate of drying and final moisture content, but makes for a longer seasonal period of stain danger. Conditions favorable to excessive drying are, also, present for a time each year.

The lumber cut of this region is very largely pine. More than 60 per cent of the annual production is composed of the western yel-

low pine of which the adopted trade name in this territory is California white pine. Sugar pine accounts for an additional 15 per cent and white fir and Douglas fir make up the bulk of the remaining cut. (Table 1.)

Air-seasoning practice in the California pine region is directly affected by certain manufacturing methods peculiar to this territory. A large proportion of selects, shop, and box lumber is cut, owing to the size of the timber and to trade demands. This results in a heavy production of stock 5/4 and thicker and the general custom has developed of cutting the greater part of the log into 6/4 stock. Such practice means that a large portion of the output is piled in random widths and lengths and that extremely wide stock is not uncommon. Sixteen feet is ordinarily the standard length.

Like most producing sections, the region employs generally a number of more or less distinctive methods in its air-seasoning practice. Wide alleys, 16 feet or over, are the rule. The foundations, almost without exception, have ample height and clearance. A very appreciable amount of thick stock is air seasoned and largely in random widths. Sixteen-foot box piles are ordinarily used, and the trend is toward high piles. The standard dimensions of special crossers are 2 by 4 inches. Stock crossers are used largely on the common and box grades. Although some plants employ adequate spacing between boards, the interval is often insufficient, particularly in random-width stock. The single, straight center chimney, 8 to 20 inches wide, is commonly used in piles of mixed widths.

RESULTS FROM PRESENT PRACTICE

The region as a whole suffers heavy air-seasoning losses, an appreciable part of which is avoidable. A careful estimate of the loss, compiled in connection with the studies made in that territory, indicated, on the basis of a drop of one grade, an average degrade of 22 per cent for all stock air seasoned. This means an actual depreciation of $2.20 for each thousand feet. The variation in degrade between yards was from 9 to 35 per cent. Such losses should provide ample incentive for improvements in air-seasoning practice.

Blue stain, to which both species of pine are susceptible, is the major cause of loss. This is to be expected in view of the large cut of pine and the regional climatic conditions. Degrade from checking is serious in all species, particularly white fir, and especially during the summer period. Losses are heaviest in the common and box grades as a result of the rather general practice of self-crossing such stock. Cupping and knot defects also contribute to the regional losses.

Although not applicable to the specific yard, Figure 8 affords a fairly good idea of the average drying rates and final moisture contents which can be obtained with present practice. From September to February a relatively long drying period is necessitated, and during only seven months of the year will stock in pile come down to an average moisture content of 15 per cent or less. Ordinarily, stock air-dry in October, if left on crossers in the yard, will thereafter begin to pick up moisture and by the end of January will contain 20 per cent or more.

RECOMMENDATIONS FOR IMPROVEMENT

The major problems for the region as a whole briefly stated are: (1) The reduction of blue stain, (2) the elimination as far as practicable of shrinkage defects, (3) faster rate of drying during the winter season, particularly in the lower part of the pile, and (4) lower final moisture contents in the inactive drying season. Suggestions for improvement of the general air-seasoning methods to meet these broad regional problems are as follows:

Sanitary measures and more attention to the reduction of vegetation in the yard are common needs.

The use of 4-foot or wider spacing between the piles at the sides should be more generally adopted.

All wood should be piled one layer to the course, other methods of pile construction more effective than double piling being employed to avoid excessively rapid drying.

Special crossers, 4 inches in width, should be utilized in piling 8-inch and wider stock of No. 3 common-and-better pine and of No. 2 common-and-better in other woods. The special crossers employed in this region are usually 2 inches thick, but special crossers 1 inch in thickness should be used on white fir and Douglas fir, especially in the upper half of the pile.

More open construction in the lower section of the lumber pile is a primary requisite for the region. This should be obtained by such methods as double stickers, horizontal openings at intervals, short chimneys in separate-width stock, and the flared chimney with random widths.

The spacing between boards in a course should be at least 4 inches for separate widths and 4/4 random-width stock; a minimum of 5 inches is advisable for 5/4 and thicker mixed widths.

Last, but of real importance, care in the actual construction of the individual pile is essential.

REDWOOD REGION

GENERAL CONDITIONS

The great bulk of production in the redwood region is concentrated within a comparatively narrow strip along the northern coast of California. Although weather conditions encountered at sea-level plants differ somewhat from those at yards located farther inland, about the same climatic characteristics prevail throughout the region. High atmospheric humidities are present at all seasons of the year but the temperature extremes are confined within a small range. The most active drying period is from May to October, but throughout the rest of the year the mean monthly temperature is always above 45° F. Such conditions, which are shown graphically in Figure 9, are conducive to relatively slow seasoning. But as a consequence, liability to depreciation from shrinkage defects is small. Also some drying is possible at all times of the year.

Redwood, of course, predominates in the cut of this region, accounting for more than 80 per cent of the production. Douglas fir is the only other wood of importance, the combined cut of white fir, spruce, and hemlock constituting less than 3 per cent of the total.

(Table 1.) It is therefore obvious that blue stain is not a factor in air seasoning. However, the high green moisture content of the redwood, together with the less favorable climatic conditions, makes for real seasoning difficulties.

Production of boards or 4/4 stock is large in the redwood region, especially in the common grades, but a big volume of thick "uppers" and shop is also cut and considerable dimension is made. Inch common is rather generally piled in separate widths. Thick shop and uppers are ordinarily seasoned in random widths. Probably 60 to 70 per cent of the production is shipped green, owing to the facilities for water transportation and the absence of the stain danger. As a result, much stock is simply stored at the plants, little or no attempt being made to obtain drying.

Drying yards in this region are almost without exception badly congested, a condition that could well be avoided where drying is slow and where a species of high moisture content is involved. This situation is probably the outgrowth of the practice of shipping green stock, as well as of a rather common shortage of yard space, and of the fact that seasoning losses are less obvious and obtrusive than in regions where stain occurs. Not only are yards crowded, but the entire air-seasoning practice is ordinarily such as to preclude anything like as rapid drying as is easily possible, even with the unfavorable conditions existing. Low foundations are the rule. Drainage and vegetation in many yards could hardly be worse. The "random-length" type of pile is often used. Wide piles are commonly employed and sometimes piled two layers to the course. The 4/4 crosser is standard for this region, and frequently an excessive number are used on each course. Spacing between boards in a course is generally inadequate, and the use of chimneys in piles of random-width stock does not follow the best practice. Finally, careless or inadequate roofing is a frequent and serious obstacle to rapid drying.

RESULTS FROM PRESENT PRACTICE

A survey of the depreciation resulting from air seasoning in the redwood region indicates an actual footage loss of 2.5 per cent which, very conservatively, means a regional average loss of $1.23 per thousand feet. Favorable natural conditions, and not air-seasoning methods, prevent much greater depreciation. But even if the depreciation loss does not appear to justify more concern, the cost to the operators of a drying period of such excessive length as is necessitated under present practice ought to do so.

Figure 9, which only attempts to picture the average regional drying situation, clearly indicates unsatisfactory seasoning. Except for stock piled in May, June, July, and August, very long drying periods are required. Also, reasonable final average moisture contents are obtained only from about June 1 to September 30. Weather conditions and the species concerned are, of course, in part responsible for such difficulties, but improper practice aggravates these inherent difficulties unnecessarily.

What does this mean to the industry? In addition to the very real objections of marketing a product of unsuitable moisture content, there is a more tangible loss. Careful estimates of the average air-seasoning in both the redwood and California pine regions will

illustrate this in a concrete manner. In California the average cost of carrying the investment in lumber while drying in the yard is about 32 cents per thousand feet, and the insurance and taxes on this lumber call for an additional 28 cents per thousand feet or a total of 60 cents. These costs for the redwood region, due to the prolonged drying period, amount to $2.18 and $0.54, respectively, or a total of $2.72. This means a cost of $2.12 per thousand in excess of that in the pine territory. Certainly this alone is a sufficient margin to justify considerable expense per thousand in improvement of air-seasoning methods.

A rather usual contention is that the lack of available space makes crowded yards unavoidable and prohibits the adoption of more open

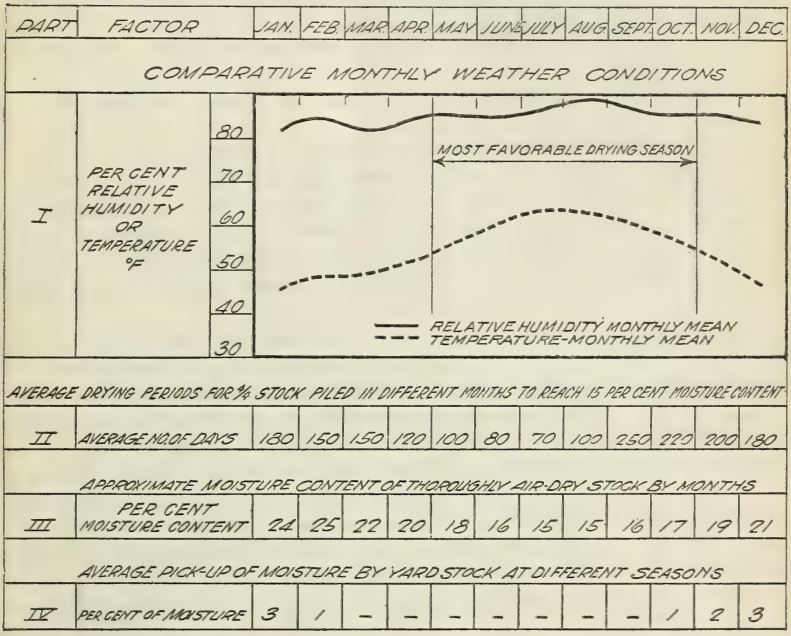


FIG. 9.—Graphic air-seasoning chart for the redwood region

piling. Some plants have very definite limitations to yard extension, it is true, but even at these plants the possibility of more rapid drying and consequent faster overturn of stocks will often warrant better practice. Another defense of current practice is to the effect that, since only stock piled in the spring and early summer will be dry enough to ship prior to the next spring, there is little use of better piling methods. This argument loses weight, however, when it is considered that the length of the average drying period can be greatly reduced by improvements in drying practice.

RECOMMENDATIONS FOR IMPROVEMENT

The protracted drying period and unsuitable final moisture content are of major importance, and reduction of checking and cupping should not be overlooked. The natural drying influences should be

utilized to the greatest possible degree by yard practice which will afford maximum air movement in both the yard and the lumber pile. The following improvements in the general regional practice are suggested:

Yard congestion should be relieved by wider alleys and wider spacing between piles at the side.

Drainage and vegetation in the yard should receive proper attention.

Higher foundations are essential.

The use of narrower piles should be thoroughly considered.

All stock should be piled one layer to the course.

The 8/4 special crosser might well be the standard for the region, as well as three crossers on 16-foot and shorter stock and four on stock of greater lengths.

A wider spacing between boards in a course with both separate and random widths is necessary.

The use of three or more chimneys, or the flared chimney with exceptionally wide stock, is desirable.

All stock should be roofed in a thorough manner.

The principal steps to reduce checking are elimination, as far as practicable, of the practice of self-crossing stock and abandonment of the random-length type of pile. At plant locations where at certain periods of the year there is liability of checking and cupping, changes in piling methods should aim primarily to open up the lower part of the pile.

The adoption of such recommendations may appear to many operators as necessitating an impracticable expansion of yard space. As a matter of fact, a large part of the expansion seemingly required is apparent only. The recommended practice should result in a reduction of the present seasoning time, thus speeding up turnover to a point where it would largely, if not entirely, compensate. There are a few yards in the redwood region where expansion is physically impossible, but at the others there is no real inability to expand. No more difficulties exist here than in the California pine region, where open yards of larger area are already accepted as common practice. The benefits to the redwood operators in freeing themselves from the grip of tradition and following the example of other regions in this respect would be even greater than they have proved to be in the California pine region.

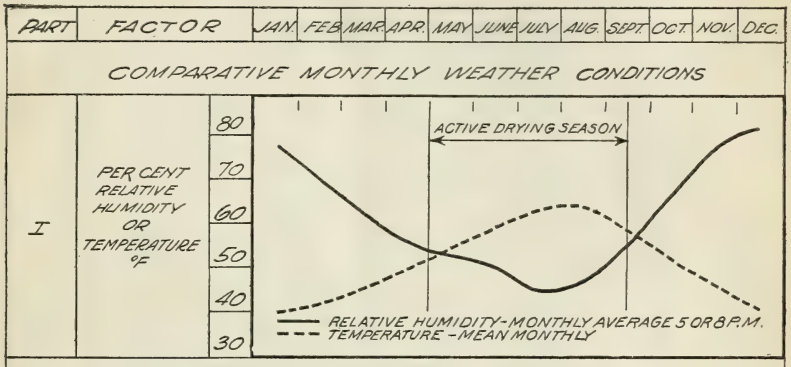
DOUGLAS FIR REGION

GENERAL CONDITIONS

The Douglas fir region of Oregon and Washington is bounded on the west by the Pacific Ocean and includes all of these two States west of the Cascade Mountains. It has a width of 70 to 170 miles and a length of 500 miles. Because the majority of the mills are located at the principal harbors, the variation in natural conditions at the different drying yards is by no means as great as would be expected in a region of this size. The climatic characteristics of this producing region are illustrated in Figure 10. Seasonal temperature fluctuation is relatively small, and mild winters are the rule. Relative humidities, however, show a marked variation at different periods

of the year and are responsible for an inactive drying season extending from about October 1 to April 30. June, July, and August are the most favorable drying months, but rarely do temperature and humidity during these months reach such extremes as to cause excessively rapid drying.

Douglas fir lumber constitutes 80 per cent of the output of this region. Next in volume is western hemlock, which constitutes 10 per cent of the total. Sitka spruce and western red cedar together account for 7 per cent. Other softwoods, including the true firs



PART	FACTOR		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
COMPARATIVE MONTHLY WEATHER CONDITIONS														
I	PER CENT RELATIVE HUMIDITY OR TEMPERATURE °F													
AVERAGE DRYING PERIODS FOR STOCK IN DIFFERENT MONTHS—AVERAGE NUMBER OF DAYS														
II	TO REACH 20 PER CENT MOISTURE CONTENT	4/4	100	80	55	35	25	20	20	15	220	190	160	130
		8/4	110	90	65	45	35	30	30	25	230	200	170	140
	TO REACH 15 PER CENT MOISTURE CONTENT	4/4	145	120	100	70	45	40	40	45	270	240	210	180
		8/4	165	140	115	90	60	55	55	320	290	260	230	200
APPROXIMATE MOISTURE CONTENT OF THOROUGHLY AIR-DRY 4/4 STOCK BY MONTHS														
III	PER CENT MOISTURE CONTENT		26	24	22	18	16	15	12	13	15	16	22	26
AVERAGE PICK-UP OF MOISTURE BY 4/4 YARD STOCK AT DIFFERENT SEASONS														
IV	PER CENT OF MOISTURE		-	-	-	-	-	-	-	-	2	2	2	2

FIG. 10.—Graphic air-seasoning chart for the Douglas fir region

and Port Orford cedar, make up less than 1 per cent of the cut. (Table 1.)

Certain characteristics of these species bear on the air-seasoning practice of the region. Little or no consideration has to be given to blue stain, either in the seasoning yard or in green shipments by rail or water. Douglas fir, western red cedar, and Sitka spruce are species of relatively low moisture content. Western hemlock is not excessively high.

In considering the extent to which air seasoning is practiced in the Douglas fir region, markets and the size of the stock cut must be taken into account. Of the total annual production in the region, probably a little less than half is shipped to domestic and foreign

TABLE 7.—*Depreciation in air seasoning and machining rough green Douglas fir common*

Stock [1]			Stock after air seasoning, and percentage of degrade				Air-seasoned stock after machining, and percentage of degrade due to machining				Total depreciation					
Grade and thickness [2] (all 8 and 12 inch widths except as noted)	Quantity		Quantities by grades [3]			De-grade [4]	Quantities by grades [3]			De-grade [5]	Degrade on the basis of volume green grade			Loss in trim-ming	Average loss in value per M feet board measure [6]		
											Season-ing	Ma-chining	Total		Season-ing	Ma-chining	Total
	Pieces	*Board feet*	*Pieces*	*Board feet*	*Per cent*	*Per cent*	*Pieces*	*Board feet*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Board feet*			
Select common—1 inch	1,417	15,163	1,192	12,764	84.18		1,074	11,561	90.58								
No. 1 common			225	2,399	15.82	15.82	118	1,203	9.42	9.42	15.82	7.93	23.75		$0.17	$0.09	$0.26
Total	1,417	15,163	1,417	15,163	100.00	15.82	1,192	12,764	100.00	9.42	15.82	7.93	23.75		.17	.09	.26
Select common—2 inch	895	24,110	798	21,096	87.50		614	17,336	82.35								
No. 1 common			97	3,003	12.45	12.45	181	3,715	17.65	17.65	12.45	15.41	27.86		.56	.69	1.25
Trims			3	11	.05	.05					.05		.05	11			
Total	895	24,110	895	24,110	100.00	12.50	795	21,051	100.00	17.65	12.50	15.41	27.91	11	.56	.69	1.25
No. 1 common—1 inch	13,624	152,143	12,451	136,832	89.94		10,473	114,317	83.86								
No. 2 common			1,125	14,429	9.48	9.48	1,884	21,087	15.47	15.47	9.48	13.85	23.34		.58	.85	1.43
No. 3 common			48	768	.50	.50	35	560	.41	.41	.50	.37	.87		.04	.03	.07
Trims			59	114	.08	.08	166	359	.26	.26	.08	.24	.32	473	.01	.04	.05
Total	13,624	152,143	13,624	152,143	100.00	10.06	12,392	136,323	100.00	16.14	10.06	14.46	24.53	473	.63	.92	1.55
No. 1 common—2 inch	4,925	131,451	4,906	130,816	99.52		4,600	122,464	94.07								
No. 2 common			19	488	.37	.37	277	7,389	5.67	5.67	.37	5.62	5.99		.02	.31	.33
Trims			29	147	.11	.11	95	334	.26	.26	.11	.25	.36	481	.02	.04	.06
Total	4,925	131,451	4,925	131,451	100.00	.48	4,877	130,187	100.00	5.93	.48	5.87	6.35	481	.04	.35	.39
No. 2 common—1 inch	1,553	18,775	1,508	18,068	96.23		1,246	14,342	79.38								
No. 3 common			45	707	3.77	3.77	262	3,638	20.13	20.13	3.77	19.38	23.15		.09	.48	.57
Trims							48	88	.49	.49		.47	.47	88		.04	.04
Total	1,553	18,775	1,553	18,775	100.00	3.77	1,508	18,068	100.00	20.62	3.77	19.85	23.62	88	.09	.52	.61
No. 2 common—2 inch [7]	592	11,847	592	11,839	99.93		579	11,539	97.73								
No. 3 common							11	216	1.83	1.83		1.82	1.82		.06	.06	
Trims			2	8	.07	.07	16	52	.44	.44	.07	.44	.51	60	.01	.05	.06
Total	592	11,847	592	11,847	100.00	.07	590	11,807	100.00	2.27	.07	2.26	2.33	60	.01	.11	.12

[1] Based on unit air-seasoning studies at 3 yerds in the Douglas fir region.
[2] A few small encased knots included in 1-inch No. 1 common, whereas present practice, as based on American lumber standards, excludes such knots.
[3] Totals in "pieces" column do not include "trims."
[4] Based on green grade volume.
[5] Based on rough-dry grade volume.
[6] Based on average price for 1921, 1922, 1923, and 1924, as reported by the West Coast Lumbermen's Association, viz: Inch select common, $16.80; inch No. 1 common, $15.70; 2-inch select common, $20.60; 2-inch No. 1 common, $16.10; inch No. 2 common, $9.55; inch No. 3 common, $7.08; 2-inch No. 2 common, $10.50; 2-inch No. 3 common, $7.08.
[7] All of this stock was 8 inches wide.

TABLE 8.—*Amount of season-check depreciation in air seasoning and machining Douglas fir common*

Green grade and size	Volume green grade	Depreciation due to season checks [1]								Depreciation due to other causes [1]	Total depreciation [1]		Moisture content of air-dry stock
		Rough air-dry stock				Machined air-dry stock [2]			Aggregate [2]		Seasoning	Machining	
		Stock	Stickers [3]	End check	Total	Stock and stickers	End check	Total					
Select common—1-inch stock:	*Board feet*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
8-inch–16-foot	13,899	4.46	4.30	0.15	8.91						16.81	3.15	17.2
12-inch–16-foot	480	3.33			3.33						3.33	23.34	15.5
8-inch–14-foot	784	1.27	4.72		5.99						5.99	83.29	14.6
Total	15,163	[4] 4.26	[4] 4.18	[4] .14	[4] 8.58						[4] 15.82	[4] 7.93	[4] 16.4
Select common—2-inch stock:													
12-inch–16-foot	16,896	11.55	4.93	.19	16.67						16.86	2.84	18.0
8-inch–16-foot	2,902	1.48			1.48						1.48	37.49	16.1
8-inch–14-foot	4,312	1.30	1.30	.25	2.85						2.85	49.79	15.9
Total	24,110	[4] 8.50	[4] 3.69	[4] .18	[4] 12.37						[4] 12.50	[4] 15.41	[4] 17.2
No. 1 common—1-inch stock:													
8-inch–16-foot	105,163	.18	.32	.10	.60	0.10	0.21	0.31	0.91	12.88	5.24	8.55	17.2
12-inch–16-foot	28,416	16.38	10.47	.50	27.35	7.55	.20	7.75	[5] 35.10	17.57	30.18	22.49	15.5
8-inch–14-foot	18,564	1.41	1.96	.06	3.43	4.49	.41	4.90	8.33	33.92	6.60	35.65	14.6
Total	152,143	[4] 3.35	[4] 2.42	[4] .17	[4] 5.94	[4] 2.02	[4] .24	[4] 2.26	[4] 8.20	[4] 16.32	[4] 10.06	[4] 14.46	[4] 16.4
No. 1 common—2-inch stock:													
12-inch–16-foot	86,912	.11		.13	.24	.48	.12	.60	.84	5.23	.46	5.61	18.0
8-inch–16-foot	26,432	.08		.11	.19	.49	.30	.79	.98	6.77	.43	7.32	16.1
8-inch–14-foot	18,107	.31		.19	.50	.11	.83	.94	1.44	4.31	.70	5.05	15.9
Total	131,451	[4] .13		[4] .13	[4] .24	[4] .43	[4] .25	[4] .68	[4] .92	[4] 5.43	[4] .48	[4] 5.87	[4] 17.2
No. 2 common—1-inch stock:													
12-inch–16-foot	10,272	1.25	5.45		6.70	21.65	.31	21.96	28.66	6.23	6.70	28.19	15.5
8-inch–14-foot	8,503		.22		.22	.87	.66	1.53	1.75	8.23	.22	9.76	14.6
Total	18,775	[4] .68	[4] 3.08		[4] 3.76	[4] 12.24	[4] .46	[4] 12.70	[4] 16.46	[4] 7.10	[4] 3.77	[4] 19.84	[4] 15.0
No. 2 common—2-inch stock:													
8-inch–16-foot	6,378			.08	.08		.20	.20	.28	1.33	.08	1.53	16.1
8-inch–14-foot	5,469			.05	.05	.35	.72	1.07	1.12	2.05	.05	3.12	15.9
Total	11,847			.07	.07	.16	.44	.60	.67	1.66	.07	2.26	16.0

[1] Based on green volume.
[2] No record kept of character of degrade in machining the select common.
[3] Regular stock used for stickers.
[4] These percentages of moisture content vary 0.1 to 0.6 per cent from the weighted average percentage based on the green volume.
[5] Includes a small amount of stock that dropped to No. 3 common.

markets by water, and the bulk of these water-borne shipments, as well as of the considerable rail shipments, is made up of green lumber. The region, moreover, is an unusually large producer of thick stock, or sizes thicker than 1 inch. Probably 30 per cent of the regional cut consists of dimension (2 inches thick), and an additional 20 per cent of planks, small and large structural timbers, squares, railroad ties, and the like. Less than 20 per cent goes into common boards.

Only an approximation of the quantity of lumber air seasoned in the Douglas fir region can be given. Practically all the manufacturing plants are equipped with dry kilns, with the exception of a few cargo mills, the tie-cutting plants, and the small portable and custom mills. Hence it is that practically all the clear lumber and a small proportion of the dimension and common boards, amounting to about 35 per cent of the total lumber cut, is dried in kilns. Fully 50 per cent of the cut is shipped green, since for the large proportion shipped by water there is no incentive to reduce the weight of the lumber through seasoning. Only about 15 per cent of the regional output is air seasoned or partially air seasoned, and this consists chiefly of dimension and common boards.

In the air-seasoning practice of the region the width of the pile alleys is generally good, but spacing at the rear and at the sides of the pile is usually inadequate. Foundations, especially in the older yards, are entirely too low. Although the box and modified-box types of pile are commonly used, the random-length type is employed to a large extent, particularly in piling No. 2 and No. 3 common boards and dimension, shiplap, and box grade lumber. Square, low piles are most frequently found. Practically all stock is self-crossed. The spacing between boards in a course will average only about 2½ inches and chimneys are little used.

RESULTS FROM PRESENT PRACTICE

Accurate records of air-seasoning depreciation in Douglas fir common as summarized in Tables 7, 8, and 9, show definitely that season check and loose knots are the principal causes of degrades. Season check, which is heaviest during the summer months, is due principally to the practice of self-crossing, which results not only in a heavy loss in the stock crossers, but also in an increased loss in the piled stock because of the crossers. "Fall-down" from loose knots is greater in machining than in seasoning, and there is little opportunity to reduce this defect in seasoning since it is in large measure due to structural causes. However, all direct seasoning losses for the region are subject to reduction by reasonable additions to the piling cost.

TABLE 9.—*Amount of degrade due to loose knots in 1-inch No. 1 common Douglas fir*

Lot No.	Total volume green	Total degrade	Degrade due to loose knots			
			Seasoning	Machining	Total	Proportion of total degrade
	Board feet	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	19,733	10.69	2.11	5.94	8.05	75.30
2	22,187	15.81	3.89	9.47	13.36	84.50
3	16,886	17.06	7.84	8.34	16.18	94.84
4	22,795	17.60	7.67	9.08	16.75	95.17
5	23,563	8.47	1.58	6.29	7.87	92.92
6	13,200	67.82	3.64	13.81	17.45	25.73
7	15,216	39.55	.32	11.04	11.36	28.72
8	8,120	52.37	3.00	24.48	27.48	52.47
9	10,444	34.37	2.94	16.81	19.75	57.46

More serious, if indirect, seasoning losses are indicated in Figure 10, which shows that with present practice long seasoning periods are required for stock piled in the period September to March. It also shows that during only seven months of the year may suitable moisture contents be obtained. Stock thoroughly air-dry in September willl pick up moisture rather rapidly until the first of the year, when it may contain as high as 26 per cent moisture. Existing climatic conditions are, of course, the primary cause of such results, but much can be done by way of seasoning practice to minimize these difficulties.

RECOMMENDATIONS FOR IMPROVEMENT

The two major air-seasoning problems of the Douglas fir region are the reduction of the drying period and the lowering of the final moisture content of stock. Prevention of checking is also of real importance. Suggestions for change in regional practice to meet these problems are as follows:

Improved yard drainage is a rather general need.

Rear alleys should be wider, and greater spacing should be allowed between the sides of the piles.

A requirement of vital importance is that of higher foundations.

The spacing between boards in a course should be increased, and three or more chimneys should be used in piles of random-width stock.

To prevent the development of season check, stock crossers should not be employed on select common and better Douglas fir, nor on No. 1 common over 8 inches in width.

The use of the random-length type of pile should be discontinued.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

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